DRAFT FINAL

SAMPLING AND ANALYTICAL PLAN FOR SEDIMENT CHARACTERIZATION AT THE STIMSON LUMBER COOLING POND

Missoula County, Montana

Prepared For:

Montana Department of Environmental Quality
P.O. Box 200901
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DEQ Contract No. 401026-TO16

March 27, 2006

Olympus Work Order No. A1534

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1.0 INTRODUCTION

Olympus Technical Services, Inc. (Olympus) has prepared this Sampling and Analytical Plan (SAP) for the Montana Department of Environmental Quality (DEQ) under DEQ Contract No. 401026-TO16. The SAP presents the sampling approach for characterizing sediment in the Stimson Cooling Pond (Site) and contains the Standard Operating Procedures (SOPs) for conducting the field sampling activities. The SAP incorporates several components, including: 1) a project description that describes the site setting and data quality objectives; 2) the Field Sampling Plan (FSP) that describes sampling procedures; 3) the Quality Assurance Project Plan (QAPjP) that describes quality assurance procedures for the field and laboratory data for the project; and, 4) the Laboratory Analytical Plan (LAP).

2.0 PROJECT DESCRIPTION

The Site is located in Bonner, Missoula County, Montana, within Section 22, Township 13 North, Range 18 West, Montana Principal Meridian at Latitude 47° 00' 24.3" North, Longitude 109° 20' 53.5" West, as shown on Figure 1. The Stimson Bonner Mill is a plywood manufacturing facility. The cooling pond collects water from various sources at the Stimson Bonner Mill including, boiler blow down water, yard runoff, and Non Contact Cooling Water (NCCW). The pond has dimensions of approximately 470 feet by 75 feet and covers an area of approximately 33,000 square feet. The water depth is variable, ranging from an estimated 1 foot in the western portion of the pond to more than 5 feet in the eastern portion of the pond. Water generally enters the western end of the pond and is discharged to the Blackfoot River at an outfall located near the eastern end.

The pond is located along the south bank of the Blackfoot River and, based on historical photographs, was constructed in the former Blackfoot River channel. The focus of the Site Characterization is to collect sediment samples from the pond and analyze the samples for a wide variety of potential contaminants.

DEQ shall repair any damage to the Site to the extent such damage arises out of the Site Characterization work performed by the DEQ and Olympus.

2.1 Project Objectives

The objective of the Site Characterization is to collect sufficient data to assess potential contaminant distribution in the sediment. The data may be used to assess sediment handling requirements should the pond need to be removed in the future. The data is needed for better understanding the physical characteristics of the sediment.

2.2 Site Setting

2.2.1 Location and Topography

The Site is located in the Blackfoot River valley at an elevation of approximately 3,300 feet above mean sea level. Regional geography is characterized by steep mountainous terrain with

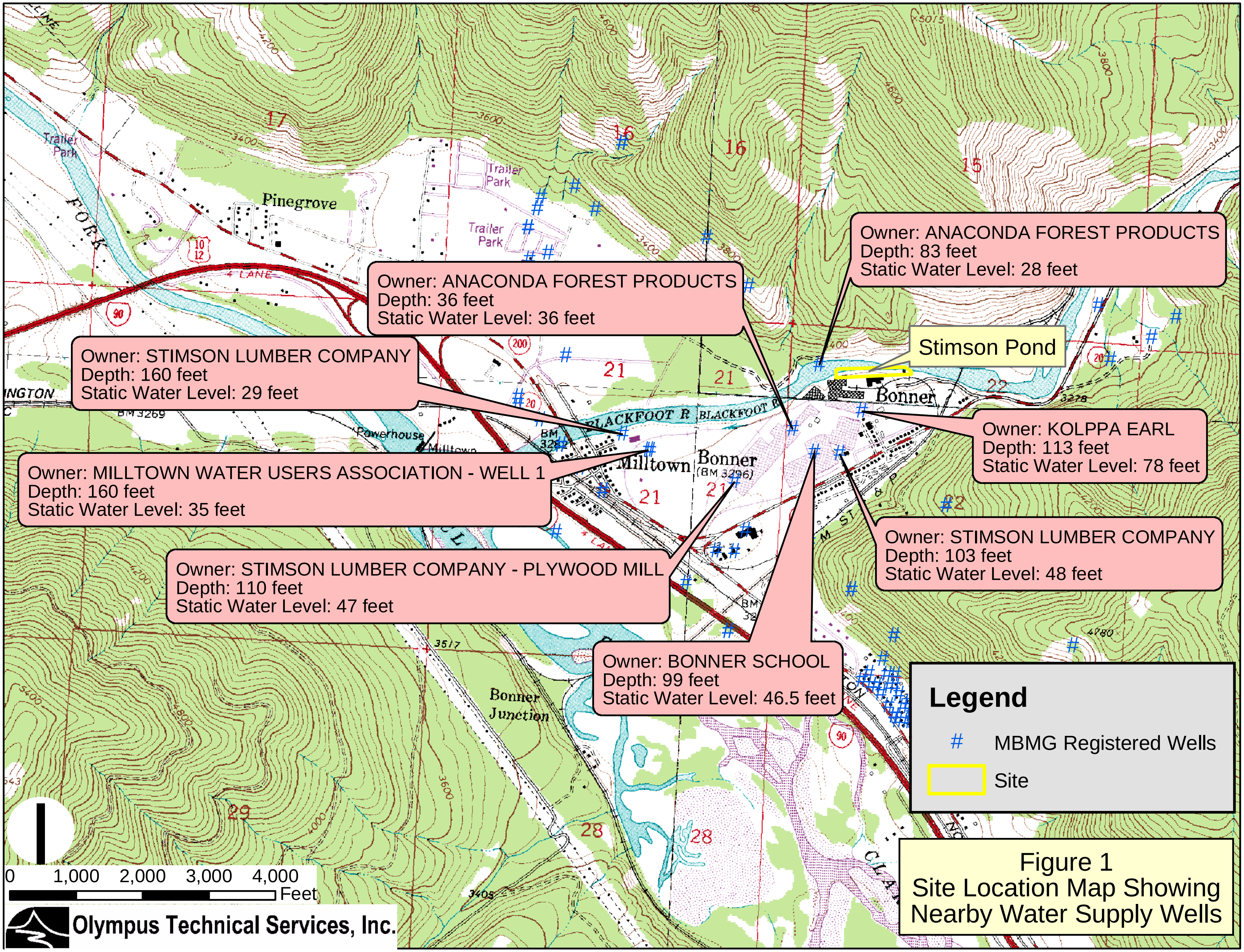

Figure 1
Site Location Map Showing Nearby Water Supply Wells

vertical relief of up to 3,000 feet. The Site lies on relatively flat terrain along the south bank of the Blackfoot River. Based on historical photographs, the pond was constructed in the former channel of the Blackfoot River. A dike separates the pond from the Blackfoot River and will provide access to the pond for sample collection.

2.2.2 Surface Water Hydrology

The Site is located on the south bank of the Blackfoot River. The Blackfoot River drains an area of approximately 2,290 square miles upstream from the Site and flows to the west in this area. The Site is located approximately 5,580 feet upstream (east) of the confluence with the Clark Fork River. The USGS Bonner gaging station is located approximately 5.5 miles upstream of the Site on the Blackfoot River. Stream flow records at that station are available for the periods of 1899 to 1905 and 1940 to present and they have ranged from approximately 200 to 19,200 cubic feet per second.

2.2.3 Geology

The geology in the region has been summarized in a geologic map by Lewis (1998). The area is characterized by folded and faulted sedimentary rocks of Pre-Cambrian age. The structures are related to Sevier style thrust faults that trend northwest-southeast. The McNamara Formation, Bonner Quartzite, Mount Shields Formation, and Shepard Formation of the Belt Supergroup form the local bedrock at the Site. These formations are composed of interbedded argillite, siltite, and quartzite. The bedrock is exposed on the north bank of the Blackfoot River across from the Site. Quaternary age alluvial sediments and anthropogenic fill overlie the bedrock at the Site.

2.2.4 Hydrogeology

Information regarding site hydrogeology was obtained from the Montana Bureau of Mines and Geology (MBMG) Ground Water Information Center (GWIC). There are 183 GWIC registered wells located within one mile of the Site. The nearest registered wells and their reported total depth and static water level are shown on Figure 1. The well locations in GWIC are often approximate and cannot be relied on without field checking. The maximum total depth of the wells located within one mile of the Site is reported to be 240 feet below ground surface (BGS) and the median total depth is reported to be 95 feet BGS. The maximum depth to static water level of these wells is reported to be 118 feet BGS and the median depth to static water level is reported to be 48 feet BGS. The minimum depth is reported as 0 feet for both total depth of well and static water level; however, if no data are available it is reported as 0 and minimum depth data is not reliable. GWIC provides drill logs for some of the wells within a 1 mile radius of the Site; available logs indicate that the wells are completed in alluvial clay, sand and gravel.

Ground water quality data for one of the Stimson Lumber Company wells was obtained from GWIC; a copy of the report is provided in Appendix A. The sample was collected on November 13, 2000, by MBMG staff and analyzed for major ions, trace elements, and basic water quality parameters. The concentrations were compared to federal and state drinking water quality standards on the table provided in Appendix A. The concentrations are below applicable water quality standards.

2.2.5 Land Use and Population

Surrounding land is used for commercial and residential purposes. The Stimson Lumber Company operates a plywood plant locate to the south of the Site. The nearest residences are located south of the Stimson Lumber Company property, approximately 1,000 feet southeast of the pond.

2.2.6 Site Development History

Information regarding development of the Site was obtained from past and current Stimson employees. The pond was built sometime after 1905 and before 1940. The pond used to be periodically dredged. Works would also put logs in the pond before going to the de-barker and this practice continued into the early 1970s.

3.0 FIELD SAMPLING PLAN

The field sampling plan addresses constituents of concern, identifies action levels for which field sampling and analytical methods must achieve, describes sampling approaches for each potential source area, and presents field sampling procedures. All field work will be conducted under the guidance of a site-specific health and safety plan (Olympus 2006a).

3.1 Constituents of Concern

No sampling has been conducted of the sediments at the pond and no constituents of concern have been identified. The pond has been used to cool boiler blow down water and as a basin for yard runoff and NCCW. Because the history of discharge to the pond is not well documented, a broad range of potential contaminants will be assessed. The groups of target analytes include ph, Eh, total metals, volatile petroleum hydrocarbons (VPH), extractable petroleum hydrocarbons (EPH), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and herbicides/pesticides. Selected samples may also be analyzed for hazardous waste characteristics using the toxic characteristic leaching procedure. A list of individual target analytes is provided in Table 1.

3.2 Data Quality Objectives

Data Quality Objectives (DQOs) have been developed to ensure that data collection is of the correct type, quality, and quantity to support defensible Site decisions. DQO development was conducted following the EPA seven-step process (EPA, 2000a).

3.2.1 Problem Statement

The Stimson Cooling Pond may require removal in the near future. The primary objective of this study is to evaluate sediment quality conditions so that sediment handling requirements can be assessed should the pond be removed. Insufficient data is currently available regarding sediment quality and characterization. The project is being conducted by the DEQ with the Stimson Lumber Company as a cooperating partner in that they are providing access to the Site. The project is subject to a restricted schedule because it has the potential to be a time-critical constraint on the Milltown Dam Removal Project. Sediment sampling is scheduled for the week of March 27, 2006. The final data summary report is due to the DEQ on May 5, 2006.

3.2.2 Decision Requirements

The primary study question addressed by this sampling program is whether there would be any restriction on handling and disposition of the sediment based on the presence of contaminants if the pond is removed. The most stringent restrictions could apply should the sediment be classified as a Resource Conservation and Recovery Act (RCRA) hazardous waste and sampling is needed to assess those characteristics. Other contaminants may also present health or environmental threats that would require that the sediment be handled in a controlled manner, be it disposal in a constructed repository or a municipal landfill.

3.2.3 Decision Inputs

Screening levels are used to evaluate the sediment quality relative to RCRA hazardous waste classification and potential health threats associated with uncontrolled disposal of the sediment. Screening levels have been established based on criteria regarding classification of wastes as RCRA hazardous and potential health threats related to a wide range of contaminant types. The screening levels presented here are not to be considered as cleanup goals, but as concentrations at which further consideration is necessary. Development of screening levels here ensures that appropriate analytical methods are used.

RCRA hazardous waste classification for materials from an unknown source is based on whether the waste leaches specified contaminants above the EPA standard, or if the material is flammable, reactive, or corrosive. The sediment quality will be assessed relative to RCRA hazardous waste listing by using the toxic characteristic leaching procedure (TCLP) analysis for metals, VOCs, SVOCs, pesticides, and herbicides, and the pH and reactivity analyses listed in Table 1. The sediment will not be analyzed for the RCRA hazardous waste characteristic of ignitability because the water-saturated environment precludes the potential for the sediment to be considered ignitable. The analytical methods, practical quantitation limits (PQLs), and regulatory standards are provided in Table 1. The selected methods have PQLs which are adequate for comparison to regulatory standards.

The potential for the sediment to contain contaminants that may pose health or environmental threats during handling or disposal will be assessed by analyzing the sediment for a broad range of organic and inorganic compounds for which regulatory levels or risk-based screening levels have been developed. The classes of compounds which will be tested include petroleum hydrocarbon compounds, VOCs, SVOCs, herbicides, pesticides, and metals. Screening levels are taken from risk-based concentrations developed by the DEQ and the U.S. Environmental Protection Agency (EPA). The selected screening levels are summarized on Table 1 along with the analytical method and PQLs. The source and basis for these screening levels are described below.

The DEQ has calculated risk-based screening levels (RBSLs) for corrective action guidance for petroleum releases (DEQ, 2003). The RBSLs are limited to petroleum hydrocarbon compounds common to petroleum release sites. The RBSLs assess human health risk from direct contact to the compounds in soil as well as leaching of those compounds to ground water. The RBSLs will be used as the screening level for compounds for which they have been developed.

Table 1. Target Analyte List and Screening Levels

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
pH, Saturated Paste	ASA Mono. #9, Part 2, Method 29-3.5.2	0.01 Std. units	<2 or >12.5 RCRA
Eh, Saturated Paste	Standard Methods 2580B	Millivolts (+/- 10%)	NA
Volatile Petroleum Hydrocarbons	Mass. Method		
Methyl t-butylether		0.03 mg/kg	0.1 mg/kg RBSL
Benzene		0.03 mg/kg	0.05 mg/kg RBSL
Toluene		0.05 mg/kg	10 mg/kg RBSL
Ethylbenzene		0.05 mg/kg	10 mg/kg RBSL
Xylenes		0.15 mg/kg	200 mg/kg RBSL
Naphthalene		0.25 mg/kg	9 mg/kg RBSL
C_9 to C_{10} Aromatics		1 mg/kg	8 mg/kg RBSL
C_5 to C_8 Aliphatics		5 mg/kg	100 mg/kg RBSL
C_9 to C_{12} Aliphatics		5 mg/kg	500 mg/kg RBSL
Total Purgeable Hydrocarbons		10 mg/kg	500 mg/kg RBSL
Total Extractable Hydrocarbons Screen	Mass. Method	10	5,000 mg/kg RBSL
Extractable Petroleum Hydrocarbons	Mass. Method		
C_9 to C_{18} Aliphatics		10 mg/kg	1,000 mg/kg RBSL
C_{19} to C_{36} Aliphatics		10 mg/kg	5,000 mg/kg RBSL
C_{11} to C_{22} Aromatics		10 mg/kg	100 mg/kg RBSL
Naphthalene		0.3 mg/kg	9 mg/kg RBSL
Acenaphthene		0.3 mg/kg	200 mg/kg RBSL
Fluorene		0.3 mg/kg	200 mg/kg RBSL
Anthracene		0.3 mg/kg	4,000 mg/kg RBSL
Fluoranthene		0.3 mg/kg	1,000 mg/kg RBSL
Pyrene		0.3 mg/kg	5,000 mg/kg RBSL
Benzo(a)Anthracene		0.3 mg/kg	10 mg/kg RBSL
Chrysene		0.3 mg/kg	1,000 mg/kg RBSL
Benzo(b)Fluoranthene		0.3 mg/kg	50 mg/kg RBSL
Benzo(a)Pyrene		0.33 mg/kg	3 mg/kg RBSL
Indeno(1,2,3-cd)Pyrene		0.33 mg/kg	10 mg/kg RBSL
Dibenzo(a,h)Anthracene		0.67 mg/kg	6 mg/kg RBSL
Benzo(g,h,i)Perylene		0.33 mg/kg	NA
Benzo(k)Fluoranthene		0.3 mg/kg	

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
Volatile Organic Compounds (VOCs)	SW 8260B		
Acetone		0.5 mg/kg	14,000 mg/kg PRG
Acrylonitrile		0.5 mg/kg	0.21 mg/kg PRG
Benzene		0.05 mg/kg	0.1 mg/kg RBSL
Bromobenzene		0.05 mg/kg	28 mg/kg PRG
Bromochloromethane		0.05 mg/kg	NA
Bromodichloromethane		0.05 mg/kg	0.82 mg/kg PRG
Bromoform		0.05 mg/kg	62 mg/kg PRG
Bromomethane		0.05 mg/kg	3.9 mg/kg PRG
n-Butylbenzene		0.05 mg/kg	240 mg/kg PRG
sec-Butylbenzene		0.05 mg/kg	220 mg/kg PRG
tert-Butylbenzene		0.05 mg/kg	390 mg/kg PRG
Carbon disulfide		0.05 mg/kg	360 mg/kg PRG
Carbon tetrachloride		0.05 mg/kg	0.25 mg/kg PRG
Chlorobenzene		0.05 mg/kg	150 mg/kg PRG
Dibromochloromethane		0.05 mg/kg	1.1 mg/kg PRG
Chloroethane		0.05 mg/kg	3 mg/kg PRG
Chloroform		0.05 mg/kg	0.22 mg/kg PRG
Chloromethane		0.05 mg/kg	47 mg/kg PRG
2-Chlorotoluene		0.05 mg/kg	NA
4-Chlorotoluene		0.05 mg/kg	NA
1,2-Dibromo-3-chloropropane		0.25 mg/kg	0.46 mg/kg PRG
1,2-Dibromoethane		0.05 mg/kg	0.032 mg/kg PRG
Dibromomethane		0.05 mg/kg	NA
1,2-Dichlorobenzene		0.05 mg/kg	600 mg/kg PRG
1,3-Dichlorobenzene		0.05 mg/kg	530 mg/kg PRG
1,4-Dichlorobenzene		0.05 mg/kg	3.4 mg/kg PRG
t-1,4-Dichloro-2-butene		0.5 mg/kg	0.0079 mg/kg PRG
Dichlorodifluoromethane		0.05 mg/kg	94 mg/kg PRG
1,1-Dichloroethane		0.05 mg/kg	510 mg/kg PRG
1,2-Dichloroethane		0.05 mg/kg	0.28 mg/kg PRG
1,1-Dichloroethene		0.05 mg/kg	120 mg/kg PRG
cis-1,2-Dichloroethene		0.05 mg/kg	43 mg/kg PRG
trans-1,2-Dichloroethene		0.05 mg/kg	69 mg/kg PRG
1,2-Dichloropropane		0.05 mg/kg	0.34 mg/kg PRG

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
Volatile Organic Compounds (VOCs), Continued			
1,3-Dichloropropane		0.05 mg/kg	100 mg/kg PRG
2,2-Dichloropropane		0.05 mg/kg	NA
1,1-Dichloropropene		0.05 mg/kg	NA
cis-1,3-Dichloropropene		0.05 mg/kg	0.78 mg/kg PRG
trans-1,3-Dichloropropene		0.05 mg/kg	0.78 mg/kg PRG
Ethylbenzene		0.05 mg/kg	10 mg/kg RBSL
Ethylmethacrylate		0.05 mg/kg	140 mg/kg PRG
Hexachlorobutadiene		0.05 mg/kg	6.2 mg/kg PRG
2-Hexanone		0.25 mg/kg	NA
Iodomethane		0.25 mg/kg	NA
Isopropylbenzene (Cumene)		0.05 mg/kg	570 mg/kg PRG
Isopropyltoluene		0.05 mg/kg	NA
Methyl-t-butyl ether		0.05 mg/kg	0.1 mg/kg RBSL
Methyl ethyl ketone		0.25 mg/kg	22,000 mg/kg PRG
Methyl isobutyl ketone		0.25 mg/kg	5,300 mg/kg PRG
Methylene chloride		0.25 mg/kg	9.1 mg/kg PRG
Naphthalene		0.05 mg/kg	9 mg/kg RBSL
n-Propylbenzene		0.05 mg/kg	240 mg/kg RBSL
Styrene		0.05 mg/kg	1700 mg/kg PRG
Tetrachloroethene		0.05 mg/kg	0.48 mg/kg PRG
1,1,1,2-Tetrachloroethane		0.05 mg/kg	3.2 mg/kg PRG
1,1,2,2-Tetrachloroethane		0.05 mg/kg	0.41 mg/kg PRG
1,2,3-Trichlorobenzene		0.05 mg/kg	NA
1,2,4-Trichlorobenzene		0.05 mg/kg	62 mg/kg PRG
1,1,1-Trichloroethane		0.05 mg/kg	1,200 mg/kg PRG
1,1,2-Trichloroethane		0.05 mg/kg	0.73 mg/kg PRG
Trichloroethene		0.05 mg/kg	0.053 mg/kg PRG
Trichlorofluoromethane		0.05 mg/kg	390 mg/kg PRG
1,2,3-Trichloropropane		0.05 mg/kg	71 mg/kg PRG
1,2,4-Trimethylbenzene		0.05 mg/kg	52 mg/kg PRG
1,3,5-Trimethylbenzene		0.05 mg/kg	21 mg/kg PRG
Toluene		0.05 mg/kg	10 mg/kg RBSL
Vinyl Acetate		0.25 mg/kg	430 mg/kg PRG
Vinyl Chloride		0.05 mg/kg	0.079 mg/kg PRG
Xylenes		0.15 mg/kg	200 mg/kg PRG

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
Semivolatile Organic Compounds (SVOCs)	SW 8270		
Acid Extractables			
4-Chloro-3-methylphenol		0.1 mg/kg	NA
2-Chlorophenol		0.1 mg/kg	63 mg/kg PRG
Total Cresols		0.1 mg/kg	NA
2-Methylphenol		0.1 mg/kg	3,100 mg/kg PRG
4-Methylphenol		0.1 mg/kg	310 mg/kg PRG
2,4-Dichlorophenol		0.1 mg/kg	180 mg/kg PRG
2,4-Dimethylphenol		0.1 mg/kg	1,200 mg/kg PRG
4,6-Dinitro-2-methylphenol		0.2 mg/kg	6.1 mg/kg PRG
2,4-Dinitrophenol		1.0 mg/kg	120 mg/kg PRG
2-Nitrophenol		0.1 mg/kg	NA
4-Nitrophenol		0.1 mg/kg	NA
Pentachlorophenol		0.2 mg/kg	3 mg/kg PRG
Phenol		0.1 mg/kg	18,000 mg/kg PRG
2,4,5-Trichlorophenol		0.1 mg/kg	6,100 mg/kg PRG
2,4,6-Trichlorophenol		0.1 mg/kg	6.1 mg/kg PRG
Base Neutral Extractables			
Acenaphthene		0.1 mg/kg	200 mg/kg RBSL
Acenaphthylene		0.1 mg/kg	NA
Anthracene		0.1 mg/kg	4,000 mg/kg RBSL
Benzo(a)anthracene		0.1 mg/kg	10 mg/kg RBSL
Benzo(b)fluoranthene		0.1 mg/kg	50 mg/kg
Benzo(k)fluoranthene		0.1 mg/kg	500 mg/kg
Benzo(g,h,i)perylene		0.1 mg/kg	NA
Benzo(a)Pyrene		0.1 mg/kg	3 mg/kg RBSL
Benzoic acid		0.2 mg/kg	100,000 mg/kg PRG
Benzyl alcohol		0.1 mg/kg	18,000 mg/kg PRG
Bis(2-chloroethoxy)methane		0.1 mg/kg	NA
Bis(2-chloroethyl)ether		0.2 mg/kg	0.22 mg/kg PRG
Bis(2-chloroisopropyl)ether		0.1 mg/kg	2.9 mg/kg PRG
Bis(2-ethylhexyl)phthalate		0.2 mg/kg	35 mg/kg PRG
4-Bromopheylphenylether		0.1 mg/kg	NA
Butyl benzyl phthalate		0.1 mg/kg	12,000 mg/kg PRG

Table 1. Target Analyte List and Screening Levels, Continued			
Target Analyte	**Analytical Method**	**Practical Quantitation Limit**	**Screening Level**
SVOCs Base Neutral Extractables, Continued			
Carbazole		0.1 mg/kg	24 mg/kg PRG
4-Chloroaniline		0.5 mg/kg	240 mg/kg PRG
2-Chloronaphthalene		0.1 mg/kg	4,900 mg/kg PRG
4-Chlorophenyl-phenylether		0.1 mg/kg	NA
Chrysene		0.1 mg/kg	1,000 mg/kg RBSL
Di-n-buyl phthalate		0.1 mg/kg	6,100 mg/kg PRG
Di-n-octyl phthalate		0.1 mg/kg	2,400 mg/kg PRG
Dibenzo(a,h)Anthracene		0.1 mg/kg	6 mg/kg RBSL
Dibenzofuran		0.1 mg/kg	150 mg/kg PRG
1,2-Dichlorobenzene		0.1 mg/kg	600 mg/kg PRG
1,3-Dichlorobenzene		0.1 mg/kg	530 mg/kg PRG
1,4-Dichlorobenzene		0.1 mg/kg	3.4 mg/kg PRG
3,3’-Dichlorobenzidene		0.5 mg/kg	1.1 mg/kg PRG
Diethyl phthalate		0.1 mg/kg	49,000 mg/kg PRG
Dimethyl phthalate		0.1 mg/kg	100,000 mg/kg PRG
2,4-Dinitirotoluene		0.1 mg/kg	120 mg/kg PRG
2,6-Dinitrotoluene		0.1 mg/kg	61 mg/kg PRG
Fluorene		0.1 mg/kg	200 mg/kg RBSL
Fluoranthene		0.1 mg/kg	1,000 mg/kg RBSL
Hexachlorobenzene		0.2 mg/kg	0.3 mg/kg PRG
Hexachlorobutadiene		0.1 mg/kg	6.3 mg/kg PRG
Hexachlorocyclopentadiene		0.1 mg/kg	370 mg/kg PRG
Hexachloroethane		0.1 mg/kg	35 mg/kg PRG
Indeno(1,2,3-cd)pyrene		0.1 mg/kg	10 mg/kg RBSL
Isophorone		0.1 mg/kg	510 mg/kg PRG
2-Methylnaphthalene		0.1 mg/kg	NA
Naphthalene		0.1 mg/kg	9 mg/kg RBSL
2-Nitroaniline		0.1 mg/kg	180 mg/kg PRG
3-Nitroaniline		0.33 mg/kg	18 mg/kg PRG
4-Nitroaniline		0.33 mg/kg	23 mg/kg PRG
Nitrobenzene		0.1 mg/kg	20 mg/kg PRG
N-Nitrosodi-n-propylamine		0.1 mg/kg	0.069 mg/kg PRG
N-Nitrosodimethylamine		0.1 mg/kg	0.0095 mg/kg PRG
N-Nitrosodiphenylamine		0.2 mg/kg	99 mg/kg PRG
Phenanthrene		0.1 mg/kg	NA

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
SVOCs Base Neutral Extractables, Continued			
Pyrene		0.1 mg/kg	5,000 mg/kg RBSL
Pyridine		0.2 mg/kg	61 mg/kg PRG
1,2,4-Trichlorobenzene		0.1 mg/kg	62 mg/kg PRG
Organochlorine Pesticides	SW 8081A		
4,4'-DDD		0.007 mg/kg	2.4 mg/kg PRG
4,4'-DDE		0.007 mg/kg	1.7 mg/kg PRG
4,4'-DDT		0.007 mg/kg	1.7 mg/kg PRG
alpha-BHC		0.003 mg/kg	NA
beta-BHC		0.003 mg/kg	NA
delta-BHC		0.003 mg/kg	NA
alpha-Chlordane		0.003 mg/kg	1.6 mg/kg PRG
gamma-Chlordane		0.003 mg/kg	1.6 mg/kg PRG
Aldrin		0.003 mg/kg	0.029 mg/kg PRG
Dieldrin		0.007 mg/kg	0.03 mg/kg PRG
Endosulfan I		0.003 mg/kg	370 mg/kg PRG
Endosulfan II		0.007 mg/kg	370 mg/kg PRG
Endosulfan sulfate		0.007 mg/kg	NA
Endrin		0.007 mg/kg	18 mg/kg PRG
Endrin Aldehyde		0.007 mg/kg	NA
Heptachlor		0.003 mg/kg	0.11 mg/kg PRG
Heptachlor epoxide		0.003 mg/kg	0.053 mg/kg PRG
Lindane (gamma-BHC)		0.003 mg/kg	NA
Methoxychlor		0.033 mg/kg	310 mg/kg PRG
Toxaphene		0.066 mg/kg	0.44 mg/kg PRG
PCBs	SW 8082		
Aroclor-1016		0.033 mg/kg	0.11 mg/kg PRG
Aroclor-1221		0.033 mg/kg	0.11 mg/kg PRG
Aroclor-1232		0.033 mg/kg	0.11 mg/kg PRG
Aroclor-1242		0.033 mg/kg	0.11 mg/kg PRG
Aroclor-1248		0.033 mg/kg	0.11 mg/kg PRG
Aroclor-1254		0.033 mg/kg	0.11 mg/kg PRG
Aroclor-1260		0.033 mg/kg	0.11 mg/kg PRG

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
Chlorinated Herbicides	SW 8151A		
2,4-D		0.05 mg/kg	690 mg/kg PRG
2,4,5-T		0.02 mg/kg	610 mg/kg PRG
2,4,5-TP		0.1 mg/kg	490 mg/kg PRG
2,4-DB		0.1 mg/kg	490 mg/kg PRG
Dalapon		0.1 mg/kg	1,800 mg/kg PRG
Dichlorprop		0.15 mg/kg	NA
Dinoseb		0.1 mg/kg	61 mg/kg PRG
Dicamba		0.02 mg/kg	1,800 mg/kg PRG
MCPA		20 mg/kg	31 mg/kg PRG
MCPP		10 mg/kg	61 mg/kg PRG
Pentachlorophenol		0.01 mg/kg	3 mg/kg PRG
Picloram		0.02 mg/kg	4,300 mg/kg PRG
Total Metals			
Aluminum	SW 6010B	20 mg/kg	76,000 mg/kg PRG
Antimony	SW 6010B	10 mg/kg	31 mg/kg PRG
Arsenic	SW 6010B	10 mg/kg	40 mg/kg DEQ
Barium	SW 6010B	10 mg/kg	5,400 mg/kg PRG
Beryllium	SW 6010B	2 mg/kg	150 mg/kg PRG
Cadmium	SW 6010B	2 mg/kg	37 mg/kg PRG
Chromium	SW 6010B	10 mg/kg	210 mg/kg PRG
Cobalt	SW 6010B	10 mg/kg	900 mg/kg PRG
Copper	SW 6010B	10 mg/kg	3,100 mg/kg PRG
Iron	SW 6010B	100 mg/kg	23,000 mg/kg PRG
Lead	SW 6010B	10 mg/kg	400 mg/kg PRG
Manganese	SW 6010B	5 mg/kg	1,800 mg/kg PRG
Mercury	SW 7471B	0.2 mg/kg	23 mg/kg PRG
Molybdenum	SW 6010B	10 mg/kg	390 mg/kg PRG
Nickel	SW 6010B	10 mg/kg	1,600 mg/kg PRG
Selenium	SW 6010B	10 mg/kg	390 mg/kg PRG
Silver	SW 6010B	10 mg/kg	390 mg/kg PRG
Thallium	SW 6020	5 mg/kg	5.2 mg/kg PRG
Vanadium	SW 6010B	10 mg/kg	78 mg/kg PRG
Zinc	SW 6010B	10 mg/kg	23,000 mg/kg PRG
Calcium	SW 6010B	100 mg/kg	NA

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
Total Metals, Continued			
Magnesium	SW 6010B	100 mg/kg	NA
Sodium	SW 6010B	100 mg/kg	NA
Potassium	SW 6010B	100 mg/kg	NA
TCLP Metals	SW 1311/SW 6010B/6020A		
Arsenic		0.5 mg/l	5.0 mg/l RCRA
Barium		0.2 mg/l	100 mg/l RCRA
Cadmium		0.1 mg/l	1.0 mg/l RCRA
Chromium		0.1 mg/l	5.0 mg/l RCRA
Lead		0.5 mg/l	5.0 mg/l RCRA
Mercury		0.001 mg/l	0.2 mg/l RCRA
Selenium		0.5 mg/l	1.0 mg/l RCRA
Silver		0.2 mg/l	5.0 mg/l RCRA
TCLP Semivolatiles	SW 1311/SW 8270C		
1,4-Dichlorobenzene		0.04 mg/l	7.5 mg/l RCRA
2,4,5-Trichlorophenol		0.04 mg/l	400 mg/l RCRA
2,4,6-Trichlorophenol		0.04 mg/l	2 mg/l RCRA
2,4-Dinitrotoluene		0.04 mg/l	0.13 mg/l RCRA
Hexachlorobenzene		0.04 mg/l	0.13 mg/l RCRA
Hexachlorobutadiene		0.04 mg/l	0.5 mg/l RCRA
Hexachloroethane		0.04 mg/l	3.0 mg/l RCRA
Nitrobenzene		0.04 mg/l	2.0 mg/l RCRA
Pentachlorophenol		0.2 mg/l	100 mg/l RCRA
Pyridine		0.2 mg/l	5.0 mg/l RCRA
Total Cresols		0.04 mg/l	200 mg/l RCRA
TCLP Volatiles	SW 1311/SW 8260B		
1,1-Dichloroethene		0.005 mg/l	0.7 mg/l RCRA
1,2-Dichloroethane		0.005 mg/l	0.5 mg/l RCRA
1,4-Dichlorobenzene		0.005 mg/l	7.5 mg/l RCRA
Benzene		0.005 mg/l	0.5 mg/l RCRA
Carbon Tetrachloride		0.005 mg/l	0.5 mg/l RCRA
Chlorobenzene		0.005 mg/l	100 mg/l RCRA
Chloroform		0.005 mg/l	6 mg/l RCRA

Table 1. Target Analyte List and Screening Levels, Continued

Target Analyte	Analytical Method	Practical Quantitation Limit	Screening Level
TCLP Metals, Continued			
Methyl ethyl ketone		0.1 mg/l	200 mg/l RCRA
Tetrachloroethene		0.005 mg/l	0.7 mg/l RCRA
Trichloroethene		0.005 mg/l	0.5 mg/l RCRA
Vinyl Chloride		0.005 mg/l	0.2 mg/l RCRA
TCLP Pesticides	SW 1311/SW 8081A		
Chlordane		0.01 mg/l	0.03 mg/l RCRA
Endrin		0.005 mg/l	0.02 mg/l RCRA
Heptachlor		0.002 mg/l	0.008 mg/l RCRA
Heptachlor epoxide		0.002 mg/l	0.008 mg/l RCRA
Lindane		0.05 mg/l	0.4 mg/l RCRA
Methoxychlor		0.5 mg/l	10 mg/l RCRA
Toxaphene		0.1 mg/l	0.5 mg/l RCRA
TCLP Herbicides	SW 1311/SW 8151A		
2,4-D		0.2 mg/l	10 mg/l RCRA
2,4,5-TP		0.1 mg/l	1 mg/l RCRA

Notes: Screening levels are based on the following sources:
RBSL indicates DEQ Tier 1 Risk-Based Screening Level for subsurface soil <10 feet to ground water (DEQ, 2003)
DEQ indicates DEQ action level for arsenic in surface soil (DEQ, 2005)
PRG indicates EPA Region 9 Preliminary Remediation Goal for residential soil (EPA, 2004)
RCRA indicates regulatory limit for designation as RCRA hazardous waste
NA indicates screening level not available

The DEQ (DEQ, 2005) has also established a baseline screening level for arsenic in soil because it often occurs at concentrations above risk-based screening levels in Montana due to natural mineralization (DEQ, 2005). The DEQ's action level for arsenic of 40 mg/kg will be used as one of the screening level for this Site.

The EPA (EPA, 2004) has adopted preliminary remediation goals (PRGs) that are used as a conservative screening level to assess whether contaminants may pose health or environmental threats. The DEQ often uses PRGs as screening levels for compounds that do not have RBSLs and they will be used in that capacity for this project. For this study and site, EPA Region 9 PRGs for residential soil will be referenced.

The practical quantitation limits (PQL) for dibromomethane, t-1, 4-Dichloro-2-butene, bis (2-chloroethyl) ether, n-nitrosodi-n-propylamine, and n-nitrosodimethylamine exceed their respective PRGs. For these compounds the PQL will serve as the screening level.

3.2.4 Study Boundaries

The study is restricted to sediments that have been deposited in the cooling pond since its construction. The boundaries of the pond are well defined a levee that separates the pond from the Blackfoot River and a steep bank that defines the southern limit of the pond. The pond has dimensions of approximately 470 feet by 75 feet and covers an area of approximately 33,000 square feet. The water depth is variable, ranging from an estimated one foot in the western portion of the pond to more than five feet in the eastern portion of the pond. Water generally enters the southern end of the pond and is discharged to the Blackfoot River at an outfall located near the northern end of the pond.

3.2.5 Decision Rule

Initial screening of the samples will be on a judgmental rather than statistical basis. The sample results will be individually compared to screening levels for a preliminary assessment of hazardous waste characterization listing. The results will also be individually compared to risk-based screening levels. Any exceedances of the screening levels will be evaluated on a case-by-case basis to identify potential restrictions on handling or disposal.

3.2.6 Decision Error Limits

Decision error limits are incorporated into section 4.2.

3.2.7 Sampling Plan

The objective of this sampling plan is to assess the chemical quality and physical characteristics of sediment in the pond. Subsurface sediment samples will be collected at four locations in the pond using a core drilling rig staged on a barge. Sample locations will be selected in the field with the goal of assessing sediment at areas where different sources discharge to the pond and near the pond outfall where a mix of all sediment sources is expected. Borings will be located in the field using a combination of a hand-held global positioning system (GPS) receiver and relative shore-line measurements.

Borings will be advanced to a depth of either 28 feet below the water level in the pond or to the point of drill rig refusal. Samples will be collected using decontaminated split-tube, Shelby tube, or piston sampling devices, depending on sediment conditions. Continuous core samples will be collected to the maximum extent practicable given sediment conditions and available sample collection devices.

The core from each boring will be divided into up to five discrete samples. The samples will be selected in the field based on observed sediment characteristics that indicate a change in material. However, one sample from each boring will be collected from the bottom six inches of the boring and one will be collected from the top one foot of the core.

3.2.8 Background Soil Sampling

The pond represents an artificial environment that receives sediment from sources at the Stimson Lumber Company. The analytical results will be compared to EPA Region 9 PRG screening levels rather than background chemistry.

3.3 Sampling Protocols

3.3.1 Field Procedures

All field activities will be conducted in accordance with the standard operating procedures (SOPs) presented in Appendix B. The SOPs cover sampling methods; sample preservation; custody, quality assurance/quality control (QA/QC) samples and procedures; equipment and personnel decontamination; and sample designation and handling.

3.3.1.1 Equipment Decontamination

All equipment will be decontaminated before collection of each sample. Equipment decontamination consists of a tap water rinse, a soap and tap water wash, a dilute nitric acid (HNO_3) rinse (10 parts distilled/deionized (DI) water to 1 part concentrated HNO_3), and a DI water rinse followed by air drying. All equipment will also be decontaminated before leaving the site to prevent off-site transport of contaminants. Decontamination wastes will be disposed of at locations on the pond banks such that drainage will return to the pond.

3.3.1.2 Sample Designation and Labeling

Split samples will be provided, upon verbal request in the field, to Stimson Lumber Company in containers to be provided by DEQ and labeled by Olympus. A sample numbering system will be used to identify the project site, the sample medium, and the specific sample location. The sample identifier will be the boring number, the letter S will indicate that the sample media is soil, and the specific sample location number will be sequentially assigned for each boring. For example, the uppermost sample collected from boring B1 will be assigned sample number B1-S-1.

Sample locations will be carefully described in the field logbook and plotted on the site sketch. All samples will be labeled in the field and will be documented with the date and time of sample collection, the sample number, any preservatives used, analyses requested, and the sampler's initials. A permanent marker will be used for labeling, and labels will be covered with clear tape and sealed and tagged.

3.3.1.3 Sample Preservation and Handling

Samples will be preserved immediately upon sample collection, if applicable. Sample preservation, containers, and holding times are listed in Table 2. All procedures strictly follow the appropriate protocols.

All samples will be stored in coolers with ice. Chain-of-custody records will be kept with the samples and custody seals will be placed on the coolers.

3.3.1.4 Documentation

All field sampling activities and non-sampling data collection will be recorded in the site log book. The field team leader is responsible for recording information including weather conditions, field crew members, visitors to the site, samples collected, the date and time of sample collection, procedures used, any field data collected, and any deviations from this SAP.

3.3.1.5 Post-Sampling Activities

All personnel must go through decontamination procedures when leaving a contaminated area. Personnel decontamination includes routine practices as well as emergency decontamination; all procedures will follow EPA protocols. All measures will be taken to prevent the spread of potentially hazardous materials to clean areas.

All potentially contaminated fluids, sampling equipment, and personal protective materials generated on-site will be containerized and disposed of properly. All wastes will be managed according to Office of Emergency and Remedial Response (OERR) Directive 9345.3-02 "Management of Investigation Derived Wastes During Site Inspections" (EPA, 1991).

All samples will be either hand-delivered or shipped via commercial carrier to the laboratories under EPA chain-of-custody procedures. Samples will be shipped in coolers, which will be kept cool with ice packs and insulated with appropriate packing material. Custody seals will protect the integrity of the samples while in transit to the laboratory.

3.3.2 QA/QC Sampling

Quality assurance/quality control (QA/QC) samples to be collected will include field duplicates and equipment rinsate blanks at a frequency of 1 per 20 natural samples collected. The QA/QC samples will be analyzed for the same parameters as the natural samples.

TABLE 2. SAMPLE PRESERVATION AND HOLDING TIMES AND ANALYTICAL METHODS AND DETECTION LIMITS

Measurement	Analytical Method (1)	Preservation	Holding Time	Sample Size/ Sample Container
pH	ASA Mono. #9, Part 2, Method 29-3.5.2	Store at 4°C	Analyze as soon as possible	50 gram/plastic or glass
Eh	Standard Methods 2580B	Store at 4°C	Analyze as soon as possible	50 gram/plastic or glass
VPH	Mass. Method	Store at 4°C	7 days to extract, 28 to analysis	125 milliliter wide-mouth glass
EPH & EPH Screen	Mass. Method	Store at 4°C	7 days to extract, 40 to analysis	125 milliliter wide-mouth glass
VOCs	SW 8260B	Store at 4°C	14 days	125 milliliter wide-mouth glass
SVOCs	SW 8270C	Store at 4°C	14 days to extract, 40 to analysis	125 milliliter wide-mouth glass
Organochlorine Pesticides	SW 8081A	Store at 4°C	14 days to extract, 40 to analysis	125 milliliter wide-mouth glass
PCBs	SW 8082	Store at 4°C	14 days to extract, 40 to analysis	125 milliliter wide-mouth glass
Chlorinated Herbicides	SW 8151A	Store at 4°C	14 days to extract, 40 to analysis	125 milliliter wide-mouth glass
Total Metals	SW 6010B/7471B	Store at 4°C	6 months, Hg 28 days	50 gram/plastic or glass
TCLP Metals	SW 1311/6010B/6020	Store at 4°C	180 days to TCLP extract (28 days for Hg), 180 days extraction to analysis (28 days for Hg)	500 grams/plastic or glass
TCLP Volatiles	SW 1311/SW 8260B	Store at 4°C	14 days to TCLP extraction, 14 days extraction to analysis	500 grams/plastic or glass
TCLP Pesticides	SW 1311/SW 8081A	Store at 4°C	14 days to TCLP extraction, 7 days TCLP extraction to method extraction, 40 days method extraction to analysis	500 grams/plastic or glass
TCLP Herbicides	SW 1311/SW 8151A	Store at 4°C	14 days to TCLP extraction, 7 days TCLP extraction to method extraction, 40 days method extraction to analysis	500 grams/plastic or glass

The duplicate sample will be generated by splitting a sample from one sampling location into two samples. The duplicate sample checks the precision of sampling data.

The equipment rinsate blanks will be collected by pouring laboratory-supplied deionized water through or over decontaminated sampling equipment into an appropriate container. The equipment rinsate blanks test for cross contamination related to sampling procedures.

3.4 Reporting

An investigation report will be prepared that summarizes characterization activities, the laboratory sample analyses, data verification, source volume estimates, and sample location maps. The data will be reviewed and recommendations made for additional work, if needed.

3.5 Schedule

The field sampling is scheduled to occur the week of March 27, 2006. The field team will generally comprise a field project manager. Laboratory analyses will be completed within a four week period after completion of the field program. A draft Site investigation report will be submitted to the DEQ within two weeks of receipt of analytical data.

4.0 QUALITY ASSURANCE PROJECT PLAN

Quality Assurance (QA) is defined as the integrated program for ensuring reliability of monitoring and measurement data. The QA program requires the generation of a site or project specific Quality Assurance Project Plan (QAPjP). This QAPjP describes quality assurance for the sediment characterization of the Stimson Cooling Pond.

The QAPjP addresses project management, quality assurance objectives, sampling procedures, sample custody, equipment operation, analytical procedures, data reduction, corrective action procedures, audit procedures, preventative maintenance, and references. Data quality objectives regarding action levels are addressed in Section 3.2 and data quality objectives specific to each sample area are addressed in Section 3.3.

4.1 Project Organization and Responsibilities

The members associated with the investigation at the Site are listed below with their titles and responsibilities.

<u>DEQ Project Officer – Keith Large</u>

The DEQ Project Officer monitors the performance of the contractor. The DEQ reviews and approves QA measures. The DEQ Project Officer consults with the Quality Assurance Manager and Field Project Manager on any deficiencies and aids in the finalization of the resolution action. The DEQ Project Officer will consult with the Stimson Lumber Company Overseer on all matters.

Stimson Lumber Company Overseer - John Chopot

The Stimson Overseer monitors the performance of the Contractor and reports any observed deficiencies to the DEQ Project Officer or the Project Quality and Assurance Manager.

Project and Quality Assurance Manager – Alan Stine, Olympus

The Project Manager will be responsible for noting deficiencies and finalizing the resolution action. The Quality Assurance Manager will be the leader of the data review, data validation, and auditing requirements. The Quality Assurance Manager will be responsible for discovering QA problems.

Laboratory Quality Assurance Manager - Subcontractor

The Laboratory Quality Assurance Manager is provided a copy of the LAP to ensure that appropriate procedures are followed during sample analysis and data package preparation.

Field Team Members – Alan Stine and Fritz Durham, Olympus

Responsible for implementation of the sampling procedures, sample custody, field equipment operation, maintenance, calibration, and standardization. Responsible for data management including data base construction and data entry after data have been analyzed and validated.

Stimson Lumber Company Onsite Coordinator- Jerry Skillings

4.2 Quality Assurance Objectives

The ability of data to meet DQOs is evaluated with Data Quality Indicators (DQIs), including precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity. The DQI methodologies for this project are presented in Table 3.

Table 3. Data Quality Indicators

DQI	Definition	Determination Methodologies
Precision	The measure of agreement among repeated measurements of the same property under identical, or substantially similar conditions; calculated as relative percent difference (RPD), calculated as. $RPD = \frac{(S - D)}{(S + D)/2} x100$ where: S = first sample value (original); and D = second sample value duplicate. Perfect precision would result in 0 percent RPD.	Use the same analytical instrument/method to make repeated analyses on the same sample. Acceptable RPDs for laboratory duplicates are 35% for solids and 20% for water. Split a sample or collect collocated samples in the field and submit both for sample handling, preservation and storage, and analytical measurements. Acceptable RPDs for field duplicates will be based on subjective assessment.

Table 3. Data Quality Indicators, continued

DQI	Definition	Determination Methodologies
Bias	The systematic or persistent distortion of a measurement process that causes errors in one direction.	Use reference materials or analyze spiked matrix samples. Acceptance or rejection is based on the percent recovery (% R) of the laboratory matrix spike in each sample. For example, perfect recovery would be 100% and an acceptable range would be 75% to 125%. Acceptable bias varies for the different analytical methods and the specific analytical method objectives will apply.
Accuracy	A measure of the overall agreement of a measurement to a known value; includes a combination of random error (precision) and systematic error (bias) components of both sampling and analytical operations.	Use reference materials or analyze spiked matrix samples. Acceptance or rejection is based on the percent recovery (% R) of the laboratory matrix spike in each sample. For example, perfect recovery would be 100% and an acceptable range would be 75% to 125%. Acceptable accuracy levels vary for the different analytical methods and the specific analytical method objectives will apply.
Representativeness	A qualitative term that expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.	Assess whether sample collection activities in conformance with all protocols outlined in the SOPs. The field equipment rinsate samples and are used to confirm that the equipment decontamination and sample handling have no effect on sample results and reported data.
Comparability	A qualitative term that expresses the measure of confidence that one data set can be compared to another and can be combined for the decision(s) to be made.	Compare sample collection and handling methods, sample preparation and analytical procedures, holding times, stability issues, and QA protocols.
Completeness	A measure of the amount of valid data needed to be obtained from a measurement system.	Compare the number of valid measurements completed with those established by the task's performance/acceptance criteria. The measurement goal will be 80% completeness. This goal takes into account the inability of any sediment sampling method to achieve 100% retrieval.

Table 3, Cont'd. Data Quality Indicators, continued

DQI	Definition	Determination Methodologies
Sensitivity	The capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest.	Establish the minimum concentration or attribute that can be measured by a method (method detection limit) or by a laboratory (quantitation limit) and compare to action levels. Applicable PQLs are listed in Table 1.

4.3 Sampling Procedures

The representativeness and quality of data collected for an environmental study depends on maintaining and following strict protocols for sampling activities. Detailed procedures for sample collection and handling are specified and documented in the FSP (Section 3.4) and corresponding SOPs (Appendix C).

4.3.1 Field Logbook

The field logbook is the written record of all data, observations, field equipment calibrations, samples, and chain-of-custody. All entries will be in waterproof ink. Any mistakes will be lined out with a single line and initialed by the person making the correction. At a minimum the entry shall include:

- purpose of sampling;
- location and description of sampling point;
- identification of sampling crew;
- time and identification of any visitors to the site;
- type, number, preservative, and volume of sample;
- date and time of sampling;
- sample identification on chain-of-custody;
- identification and type of any QA/QC samples;
- date and time of shipping;
- weather;
- field measurements; and,
- any deviations from SOPs or Work Plan.

4.4 Sample Control, Documentation, and Shipping

The SOPs for sample handling, shipping, and related matters are discussed in Section 3.4. Samples will be packaged and shipped according to the U.S. Department of Transportation (DOT) and EPA regulations. The purpose of these procedures is to maintain the integrity of all samples during collection, transportation, analysis, and reporting.

4.5 Field Quality Assurance/Quality Control Samples

The following types of quality assurance/quality control (QA/QC) samples will be collected in the field and shipped to the lab. These samples will be shipped to the laboratory as blind QA/QC samples, identified as if they are normal environmental samples.

4.5.1 Field Duplicate

The field duplicates are split samples collected from the same sampling location identically and consecutively over a minimum period of time. These samples are prepared by collecting an aliquot of subdivided samples after appropriate mixing and homogenization has been performed. Field duplicates can be provided to another party at their request (split sample). Field duplicates will be collected at a minimum frequency of 1 per 20 samples for all media. Field duplicates will be used to assess precision.

4.5.2 Equipment Rinsate Blank

An equipment rinsate blank consists of deionized water poured through decontaminated field equipment. An equipment rinsate will be prepared at a minimum frequency of 1 per 20 samples for all media. Equipment rinsate blanks will be used to assess representativeness and to verify that decontamination of sampling equipment was complete.

4.5.3 Field Background

The field background samples provide local concentrations of analytes. The requirements for sample collection procedures, collection conditions, and collection frequency are specified in the FSP (Section 3.3.15).

4.6 Sample Custody

4.6.1 Chain-Of-Custody

A required part of any sampling and analytical program is the integrity of the sample from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the sample's history is referred to as chain-of-custody (COC). A sample is considered to be under a person's custody if it is in a person's physical possession, in view of the person after taken possession, or secured by that person so that no one can tamper with the sample. The components of the field COC (COC form, labels, and custody seals) and lab COC (COC record, sample login/logout, sample storage records, and disposal records) are described in this section.

4.6.2 Chain-Of-Custody Form

A COC form will be completed and accompany every sample. The form includes the following information:

- Project code;
- Project name;
- Samplers signature;
- Sample identification;
- Date sampled;
- Time sampled;

- Preservatives;
- Analysis requested;
- Remarks;
- Relinquishing signature, date, and time; and
- Receiving signature, date, and time.

4.6.3 Sample Labels

Sample labels are necessary to prevent misidentification of samples. Self-adhesive labels are used and include the following information:

- Sample identification;
- Sampler's initials;
- Sampling date;
- Sampling time; and
- Preservative.

4.6.4 Custody Seals

Custody seals are used to detect unauthorized tampering with samples following sample collection during shipment up to the time of analysis. Custody seals will be applied to the shipping containers when the samples are released from the sampler's custody.

4.6.5 Laboratory Custody

Laboratory custody will conform to procedures established for the Contract Laboratory Program (CLP). These procedures include:

- designation of sample custodian;
- correct completion of the COC form, recording of sample identification numbers, and documentation of sample condition upon receipt;
- laboratory sample tracking and documentation procedures; and,
- secure sample storage.

The sample will be delivered to the lab for analysis in order to perform requested analyses within the specified allowable holding times. The samples will be delivered to the person in the lab who is authorized to receive samples (laboratory sample custodian).

4.7 Equipment Operation, Maintenance, Calibration, and Standardization

All field and lab equipment will be operated, maintained, calibrated, and standardized in accordance with the EPA and manufacturer's recommended procedures. The SOPs (Appendix C) contain the field equipment operation, maintenance, calibration, and standardization procedures. The analytical method references contain the laboratory equipment operation, maintenance, calibration, and standardization procedures.

4.8 Analytical Procedures

The analytical methods to be used during the Site investigation are presented in Table 2. Laboratory analysis of samples collected during the course of this study will be performed by labs that have established protocols and QA procedures that meet or exceed EPA guidelines. EPA approved methods will be used for all applicable parameters. The laboratory standards which must be met for the project are outlined in the LAP (Section 5).

4.9 Data Reduction, Validation, Evaluation, and Reporting

4.9.1 Data Reduction

Data reduction is performed in the laboratory in conformance with the procedures outlined in the applicable method references. When EPA methods are used, the applicable data reduction procedures in the EPA method are used.

4.9.2 Data Validation

The primary data validation activities are performed by the laboratory during reduction of the laboratory data. The laboratory will review all surrogate recoveries, method blank analyses and matrix spike/matrix spike duplicate samples to verify that the analytical methods were properly performed and that no machine contamination affected the sample results. If necessary, the laboratory validation process will result in "result qualifiers" with the presented data. Table 4 presents result qualifiers that may be used. Olympus validates data by reviewing the laboratory QA/QC data and verifying the completeness of the laboratory data validation process. Olympus will also review the laboratory precision with the results of any duplicate samples submitted to the laboratory as separate investigation samples. When applicable, data results presented with result qualifiers will be reported as concentrations with "data qualifiers". Data qualifiers are derived from the "USEPA Contract Laboratory Program National Functional Guidelines Inorganic Data Review," (EPA, 1994) and the “USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review” (EPA, 1999).

TABLE 4. DATA QUALIFIERS

- U - The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
- J - The associated value is an estimated quantity.
- N - The analysis indicates the presence of an analyte for which there is presumptive evidence to make a “tentative identification”.
- UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
- R - The data are unusable. (Note: Analyte may or may not be present.)

Knowing the limitations of the data assists the data user when making interpretations. Data with limitations are usable for evaluation as long as the limitations are considered.

4.9.3 Data Evaluation

Data evaluation is performed in the office after data validation is complete. Data evaluation will be conducted to assess the DQIs in regards to meeting the DQOs.

4.9.4 Data Reporting

Data reporting begins with transferring the validated analytical results and field measurements to the computerized database. Olympus will use Microsoft Excel software for transferring data to the DEQ. DEQ will use Microsoft Excel to transfer the data to Stimson lumber Company. Data reporting continues with a printout of the analytical results and field measurements database and the interpretation of the analytical results and field measurements. The QC Summary Results, validation summaries, and computerized database will be presented to the DEQ at the completion of the project.

4.10 Corrective Action Procedures

Lab equipment malfunctions are handled by the chemist according to the equipment specifications and EPA analytical method specifications. Lab QC samples (calibration samples, method blanks, matrix spike samples, laboratory control samples, and lab duplicates) will be handled according to the EPA analytical method specifications.

4.11 Audit Procedures

An internal audit of all field procedures will be performed by the Quality Assurance Manager prior to any field work. The internal audit will include a review of procedures selected for the sampling program, a review of the QA/QC samples required, and a review of training requirements. The lab is required to have written procedures addressing internal QA/QC.

An external audit of all field procedures will be performed at the discretion of the DEQ Project Officer. External audit reports with recommended corrective action will be submitted by the DEQ Project Officer to the Quality Assurance Manager and the Field Project Officer. The Stimson Lumber Company may also request a copy from DEQ.

4.12 Preventative Maintenance

Preventative maintenance of equipment is essential if project resources are to be used in a cost effective manner. Critical spare parts will be available in the field. These spare parts include batteries, and film. The laboratory should have all necessary spare parts available for instrument repair.

5.0 LABORATORY ANALYTICAL PLAN

This Laboratory Analytical Plan (LAP) describes laboratory requirements for analysis of samples collected during the reclamation investigation. Analysis of solids (paint, concrete, soil, and wipes) and water will be conducted. All laboratory analytical work will follow the requirements listed in this document for the duration of the project. The LAP contains sections describing laboratory requirements, quality assurance requirements, and analytical methods.

5.1 Laboratory Requirements

Laboratories will be contracted through DEQ. All laboratories contracted for the project will be supplied with this document and will be required to meet the baseline data quality requirements outlined for the project in this document. All analyses performed by the project laboratories will follow the analytical methods listed in Table 2.

5.1.1 Qualifications and Experience

The laboratory shall have a rigorous and thorough internal Quality Assurance/Quality Control (QA/QC) program that reviews and validates all data generated and reported for the project. The QA/QC plan should be available in a written format that reviews the processes and designates key QA individuals by name and defines their responsibilities. The plan should include strict internal sample custody procedures from the time of sample receipt. The plan shall provide details for identifying out of control laboratory analyses and corrective actions for these conditions. The laboratory shall have a set of internal standard operating procedures (SOPs) that outline the laboratory analytical methodologies derived from USEPA reference methods and provide the methods of data reduction to determine the reported concentrations. The laboratory must also provide storage of all raw data for a period of at least two years after completion of the analyses.

5.1.2 Subcontracting

If necessary, subcontracting portions of this work by the primary laboratories is acceptable for special analyses. However, the need for any subcontracting must be approved by both the DEQ Project Officer and the Olympus Project Manager. All laboratories involved in this project must abide by the LAP and the QAPjP (Section 4). Sample custody procedures must be maintained with any subcontracted analyses. Olympus will generally send samples directly to laboratories that will provide the required analyses.

5.1.3 Confidentiality

The analytical results will be treated as strictly confidential and should not be discussed with any persons other than the Stimson Lumber Company Overseer unless identified by the Olympus Project Manager or approved by both the DEQ Project Officer and the Stimson Lumber Company Overseer.

5.1.4 Reporting Times

The analytical results will be reported within 20 working days of sample receipt by the laboratory. When possible, the sample holding, preparation, analysis and reporting times should be minimized.

5.1.5 Reporting Format

The data analyses will be performed in conformance with EPA methods referenced in Table 2. While the analyses are performed at Analytical Support Level (ASL) IV, the reporting package will be delivered with standard ASL III information to reduce the overall project costs and amount of paper generated. However, the project laboratory must maintain all raw data, including internal QA/QC data, to support generation of the Contract Laboratory Program (CLP) ASL IV data package, if requested. The laboratory must save the data for a minimum of two years following completion of the analyses. Prior to disposal of any archived data, the laboratory should contact Olympus, DEQ, and Stimson Lumber Company and obtain written permission to determine the final disposition of the data support material.

The data support package provided as a deliverable will include the following:

1. Cover letter documenting analytical protocols used.

2. Copies of completed chain-of-custody forms.

3. Cross-reference table of contractor and laboratory ID numbers.

4. Data summary tables (hard copy and magnetic media in format to be negotiated between Olympus and the laboratory).

5. QA/Quality Control (QC) Summaries including Laboratory Control Samples (LCS), spikes, duplicates, and preparation blank results.

5.1.6 Report Transmittal

All data reporting deliverables are to be sent directly to Olympus Technical Services, Inc., 765 Colleen, Helena, Montana 59601, in care of Mr. Alan Stine, Project Manager.

5.2 Quality Assurance Requirements

The external mechanism used to monitor the precision and accuracy of laboratory analyses to generate environmental data is the analysis of field and laboratory quality control (QC) samples. The required field QC types and frequency are provided in the QAPjP (Section 4). Laboratory QC requirements include method blanks, duplicates, laboratory control samples, matrix spike (MS) and matrix spike duplicate (MSD) samples. The QC requirements are to be performed 1 per 20 samples. The ranges for precision (duplicates) and accuracy (matrix spikes) acceptability are presented in the QAPjP (Section 4). The method blank should have a reported value at the method detection limit.

Calibration procedures and sample preparation procedures are part of the analytical methods listed in Table 2. The calibration procedures should be documented in a calibration logbook for each machine. Any laboratory QA/QC performance audits will be initiated by the DEQ project officer. No audits are currently scheduled to be performed for this project.

If a dilution is necessary, both the original and dilution result must be delivered. Appropriate clean-up procedures must be followed to minimize matrix effects on detection limits.

5.3 Analytical Methods and Sample Custody

Analytical methods are summarized in Table 2. The project laboratories should contact the Project Manager, Mr. Alan Stine or the DEQ Project Officer, Mr. Keith Large for permission to deviate from the listed analytical methods for any of the project analyses. All such deviations shall be reported to Stimson Lumber Company.

5.3.1 Analytical Detection Limits

All instrumentation utilized for the project must be sensitive enough to meet the required detection limits to meet the data quality objectives defined in Section 3.2 and Table 2.

5.3.2 Sample Storage Requirements

The contracted laboratory is required to have a secured sample bank for storage of samples, digestates, and extracts. Original samples will be stored in the sample bank for a standard six month interval. All other forms of the sample to be analyzed will be stored in this area for the standard six month interval after analysis or to the end of the analyte holding time, whichever comes first. The sample storage must be maintained to provide Olympus with time to review data and request re-analysis, if necessary. At the end of six months time, the laboratory will be responsible for sample disposal.

5.3.3 Laboratory Internal Chain of Custody

A sample is physical evidence collected from a facility or from the environment representative of site conditions. An essential part of hazardous waste investigations is that samples and data results may be used as evidence in legal proceedings.

Laboratories performing analyses will use document control and chain-of-custody procedures as specified by the appropriate analytical method.

5.3.4 Sample Stream

In accordance with EPA procedures, field QC samples (duplicates, blanks, and equipment rinsates) will be treated in the same manner as the standard samples. This provides external QC checks of laboratory data results.

6.0 REFERENCES

DEQ, 2003, Montana Tier 1 Risk Based Corrective Action Guidance for Petroleum Releases

DEQ, 2005, Remediation Division Action Level for Arsenic in Soil

EPA, 1994, USEPA contract laboratory program national functional guidelines for inorganic data review. EPA 540/R-94/013.

EPA, 1996, Soil screening guidance: user's guide. Publication 9355.4-23

EPA, 1999, USEPA contract laboratory program national functional guidelines for organic data review. EPA 540/R-99/008.

EPA, 2000, Guidance for the Data Quality Objectives Process. EPA QA/G-4, EPA/600/R-96/055.

EPA, 2004, EPA Region III Risk-Based Concentration Table.

Olympus 2006, Health and Safety Plan for Stimson Pond Sediment Characterization

APPENDIX A

MBMG WATER QUALITY DATA

Drinking water limits are based on U.S. Environmental Protection Agency primary and secondary standards for public water supplies (view their standards). Stock water and irrigation water recommendations are from U.S. Department of Agriculture Natural Resources Conservation Service water-quality guidelines. The guidelines are general and my vary depending on specific applications. Irrigation guidelines are based on continuous irrigation.

Sample Id	GWIC Id	Sample Date	Site Name	Location	Site Type
2001Q0975	178544	11/14/2000 2:15:00 PM	STIMSON LUMBER COMPANY	13N 18W 22 BCAD	WELL

Constituent	This Sample	Drinking Water	Stock Water	Irrigation Water
Calcium (Ca)	30.800 mg/L	---	---	---
Magnesium (Mg)	10.200 mg/L	---	2,000 mg/L	---
Sodium (Na)	3.630 mg/L	250 mg/L [smcl]	2,000 mg/L	see SAR
Potassium (K)	1.090 mg/L	---	---	---
Iron (Fe)	<.005 mg/L	0.3 mg/L [smcl]	---	---
Manganese (Mn)	<.001 mg/L	0.05 mg/L [smcl]	---	2.0 mg/L
Silica (SiO2)	10.600 mg/L	---	---	---
Bicarbonate (HCO3)	152.700 mg/L	---	---	---
Carbonate (CO3)	0.000 mg/L	---	---	---
Chloride (Cl)	0.993 mg/L	250 mg/L [smcl]	1,500 mg/L	---
Sulfate (SO4)	5.870 mg/L	250 mg/L [smcl]	1,500 mg/L	[b]
Nitrate (NO3 as N)	0.336 mg/L	10 mg/L [mcl]	100 mg/L	---
Fluoride (F)	<.05 mg/L	4 mg/L [mcl]	2 mg/L	---
Ortho-Phosphate (as P)	<.05 mg/L	---	---	---
Aluminum (Al)	<30 ug/L	50-200 ug/L [smcl]	---	1,000 ug/L
Antimony (Sb)	<2 ug/L	6 ug/L [mcl]	---	---
Arsenic (As)	1.510 ug/L	10 ug/L [mcl]	50 ug/L	100 ug/L
Barium (Ba)	216.000 ug/L	2,000 ug/L [mcl]	---	---
Boron (B)	<30 ug/L	---	---	---
Cadmium (Cd)	<2 ug/L	5 ug/L [mcl]	10 ug/L	5 ug/L
Chromium (Cr)	2.710 ug/L	100 ug/L [mcl]	1,000 ug/L	100 ug/L
Cobalt (Co)	<2 ug/L	---	1,000 ug/L	50 ug/L
Copper (Cu)	2.420 ug/L	1,300 ug/L [mcl]	500 ug/L	200 ug/L
Lead (Pb)	2.360 ug/L	15 ug/L [mcl]	50 ug/L	5,000 ug/L
Lithium (Li)	4.610 ug/L	---	---	2,500 ug/L
Molybdenum (Mo)	<10 ug/L	---	---	5 ug/L
Nickel (Ni)	<2 ug/L	---	---	200 ug/L
Phosphate (P)	<.05 ug/L	---	---	---
Selenium (Se)	<1 ug/L	50 ug/L [mcl]	50 ug/L	20 ug/L
Silver (Ag)	<1 ug/L	100 ug/L [smcl]	---	---
Strontium (Sr)	100.000 ug/L	---	---	---
Titanium (Ti)	<1 ug/L	---	---	---
Vanadium (V)	<5 ug/L	---	---	---
Zinc (Zn)	18.300 ug/L	5,000 ug/L [smcl]	24,000 ug/L	2,000 ug/L
Zirconium (Zr)	<2 ug/L	---	---	---

Key: **NR** = No reading in GWIC; **mg/L** = milligrams per Liter; **ug/L** = micrograms per Liter; --- = Currently no standard for this constituent; **[b]** = High concentrations of sulfate may restrict calcium uptake by crops; **[c]** = Varies with crop, generally dissolved solids should be less than 2,000 mg/L (equivalent to specific conductance of about 2,000 to 3,000 micromhos/cm); **[d]** = Dependent upon other variables such as type of clay in soil and salt content of water. (See SAR); **[mcl]** = U.S. Environmental Protection Agency maximum contaminant level or action level: revised October 13, 1999; **[smcl]** = U.S. Environmental Protection Agency maximum contaminant level or action level: revised October 13, 1999. This standard is based on aesthetic quality of water (i.e. odor, color, etc.) and is not a health standard.

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
ANACONDA FOREST PRODUCTS

Plot this site on a topographic map

Location Information

GWIC Id: 68166
Location (TRS): 13N 18W 22 BCB
County (MT): MISSOULA
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:

Source of Data: LOG
Latitude (dd): 46.8737
Longitude (dd): -113.8692
Geomethod: TRS-SEC
Datum: NAD27
Altitude (feet):
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 36.00
Static Water Level (ft): 36.00
Pumping Water Level (ft):
Yield (gpm): 200.00
Test Type:
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled: HAND DUG
Driller's Name:
Driller License:
Completion Date (m/d/y): 1/1/1895
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 111ALVM
Well/Water Use: DOMESTIC

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

No Seal Records currently in GWIC.

Casing Information[1]

No Casing Records currently in GWIC.

Completion Information[1]

No Completion Records currently in GWIC.

Lithology Information

No Lithology Records currently in GWIC.

[1] - All diameters reported are **inside** diameter of the casing.

information is considered unpublished and is subject to correction and review on a daily basis. The Bureau warrants the accurate transmission of the data to the original end user. Retransmission of the data to other users is discouraged and the Bureau claims no responsibility if the material is retransmitted. Note: non-reported casing, completion, and lithologic records may exist in paper files at GWIC.

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
STIMSON LUMBER COMPANY

Plot this site on a topographic map
View Water Quality for this Site

Location Information

GWIC Id: 178544
Location (TRS): 13N 18W 22 BCAD
County (MT): MISSOULA
DNRC Water Right: W116473-00
PWS Id: 00467002
Block:
Lot:
Addition:

Source of Data: COMBO
Latitude (dd): 46.8728
Longitude (dd): -113.8663
Geomethod: NAV-GPS
Datum: NAD27
Altitude (feet): 3301.00
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 103.00
Static Water Level (ft): 48.00
Pumping Water Level (ft):
Yield (gpm): 500.00
Test Type:
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs): 0.00

How Drilled:
Driller's Name: ULRICH
Driller License: WWC016
Completion Date (m/d/y): 3/17/1942
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 112ALVM
Well/Water Use: PUBLIC WATER SUPPLY

Well Notes: COMPLETION OPEN BOTTOM WITH BARS WELDED ACROSS BOTTOM OF 10 INCH PIPE.

Hole Diameter Information

From	To	Diameter
0.0	103.0	12.0

Annular Seal Information

No Seal Records currently in GWIC.

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-1.0	100.0	12.0				50 LB STEEL
96.0	103.0	10.0				STEEL

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
96.0	103.0	10.0			20 1 X 6 SLOTS

Lithology Information

From	To	Description
0.0	40.0	GRAVEL AND BOULDERS VERY LITTLE CLAY
40.0	45.0	FINE CLEAN GRAVEL AND LITTLE WATER
45.0	50.0	GRAVEL AND BIG BOULDERS
50.0	80.0	COARSE WASH GRAVEL AND WATER
80.0	85.0	CLAY AND GRAVEL MIX
85.0	90.0	COARSE WASH GRAVEL AND WATER
90.0	95.0	TIGHT CLAY AND GRAVEL
95.0	97.0	CLAY AND SAND
97.0	103.0	COARSE CLEAN GRAVEL AND SAND - WATER

1 - All diameters reported are **inside** diameter of the casing.

These data represent the contents of the GWIC databases at the Montana Bureau of Mines and Geology at the time and date of the retrieval. The

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
BONNER SCHOOL

Plot this site on a topographic map

Location Information

GWIC Id: 163171
Location (TRS): 13N 18W 22 BC
County (MT): MISSOULA
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:

Source of Data: LOG
Latitude (dd): 46.8728
Longitude (dd): -113.8678
Geomethod: TRS-SEC
Datum: NAD27
Altitude (feet):
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 99.00
Static Water Level (ft): 46.50
Pumping Water Level (ft): 80.00
Yield (gpm): 150.00
Test Type: AIR LIFT
Test Duration: 1.00
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):

Well Notes:

How Drilled: ROTARY
Driller's Name: CAMP
Driller License: WWC007
Completion Date (m/d/y): 7/31/1997
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 112ALVM
Well/Water Use: DOMESTIC
IRRIGATION

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

From	To	Description
0.0	20.0	CEMENT

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
-2.0	99.0	6.0				STEEL

Completion Information[1]

From	To	Dia	# of Openings	Size of Openings	Description
83.5	98.5	6.0			.25X1.25 SLOTS

Lithology Information

From	To	Description
0.0	3.0	TOPSOIL
3.0	55.0	SAND & GRAVEL & CLAY
55.0	99.0	SAND GRAVEL CLAY WATER

[1] - All diameters reported are **inside** diameter of the casing.

Ground-Water Information Center

Site Name: STIMSON LUMBER COMPANY

Water Quality Report

Report Date: 3/21/2006

Compare to Water Quality Standards

Location Information

Sample Id/Site Id:	2001Q0975 / 178544	**Sample Date:**	11/14/2000 2:15:00 PM
Location (TRS):	13N 18W 22 BCAD	**Agency/Sampler:**	MBMG / PMN
Latitude/Longitude:	46° 52' 22" N 113° 51' 58" W	**Field Number:**	PWS0046
Datum:	NAD27	**Lab Date:**	12/7/2000
Altitude:	3301.00	**Lab/Analyst:**	MBMG / JMC
County/State:	MISSOULA / MT	**Sample Method/Handling:**	PUMPED / 3120
Site Type:	WELL	**Procedure Type:**	DISSOLVED
Geology:	112ALVM	**Total Depth (ft):**	103.000
USGS 7.5' Quad:	BONNER	**SWL-MP (ft):**	NR
PWS Id:	00467002	**Depth Water Enters (ft):**	96.000
Project:	PWSINV		

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	30.800	1.537	Bicarbonate (HCO3)	152.700	2.503
Magnesium (Mg)	10.200	0.839	Carbonate (CO3)	0.000	0.000
Sodium (Na)	3.630	0.158	Chloride (Cl)	0.993	0.028
Potassium (K)	1.090	0.028	Sulfate (SO4)	5.870	0.122
Iron (Fe)	<.005	0.000	Nitrate (as N)	0.336	0.024
Manganese (Mn)	<.001	0.000	Fluoride (F)	<.05	0.000
Silica (SiO2)	10.600		Orthophosphate (OPO4)	<.05	0.000
Total Cations		2.565	**Total Anions**		2.677

Trace Element Results (µg/L)

Aluminum (Al):	<30	Cadmium (Cd):	<2	Mercury (Hg):	NR	Tin (Sn):	NR
Antimony (Sb):	<2	Chromium (Cr):	2.710	Molybdenum (Mo):	<10	Titanium (Ti):	<1
Arsenic (As):	1.510	Cobalt (Co):	<2	Nickel (Ni):	<2	Thallium (Tl):	<5
Barium (Ba):	216.000	Copper (Cu):	2.420	Silver (Ag):	<1	Uranium (U):	NR
Beryllium (Be):	<2	Lead (Pb):	2.360	Selenium (Se):	<1	Vanadium (V):	<5
Boron (B):	<30	Lithium (Li):	4.610	Strontium (Sr):	100.000	Zinc (Zn):	18.300
Bromide (Br):	<50					Zirconium (Zr):	<2

Field Chemistry and Other Analytical Results

**Total Dissolved Solids:	138.760	Field Hardness as CaCO3 (mg/L):	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents:	216.240	Hardness as CaCO3 (mg/L):	118.890	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	254.000	Field Alkalinity as CaCO3 (mg/L):	NR	PCP (µg/L):	NR
Lab Conductivity (µmhos):	256.000	Akalinity as CaCO3 (mg/L):	125.240	Phosphate, TD (mg/L as P):	<.05
Field pH:	7.600	Ryznar Stability Index:	8.377	Field Nitrate (mg/L):	NR
Lab pH:	7.450	Sodium Adsorption Ratio:	0.150	Field Dissolved O2 (mg/L):	NR
Water Temp (°C):	8.700	Langlier Saturation Index:	-0.464	Field Chloride (mg/L):	NR
Air Temp (°C):	-8.000	Nitrite (mg/L as N):	<.05	Field Redox (mV):	NR

Notes

Sample Condition: CLEAR

Field Remarks:

Lab Remarks:

Explanation: **mg/L** = milligrams per Liter; **µg/L** = micrograms per Liter; **ft** = feet; **NR** = No Reading in GWIC

Qualifiers: **A** = Hydride atomic absorption; **E** = Estimated due to interference; **H** = Exceeded holding time; **J** = Detected above MDL but less than MRL; **K** = Na+K combined; **N** = Spiked sample recovery not within control limits; **P** = Preserved sample; **S** = Method of standard additions; **U** = Analyzed for but not detected above MDL; * = Duplicate analysis not within control limits; ** = Sum of Dissolved Constituents is the sum of major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO3, CO3, SO4, Cl, SiO2, NO3, F) in mg/L. Total Dissolved Solids is reported as equivalent weight of evaporation residue.

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
KOLPPA EARL

Plot this site on a topographic map

Location Information

GWIC Id: 68161
Location (TRS): 13N 18W 22 B
County (MT): MISSOULA
DNRC Water Right:
PWS Id:
Block: 4
Lot: 10
Addition: WEST RIVERSIDE

Source of Data: LOG
Latitude (dd): 46.8746
Longitude (dd): -113.8651
Geomethod: TRS-SEC
Datum: NAD27
Altitude (feet):
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 113.00
Static Water Level (ft): 78.00
Pumping Water Level (ft):
Yield (gpm): 25.00
Test Type:
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled:
Driller's Name:
Driller License:
Completion Date (m/d/y): 1/1/1947
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 112ALVM
Well/Water Use: DOMESTIC

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

No Seal Records currently in GWIC.

Lithology Information

From	To	Description
0.0	113.0	GRAVEL ROCK CLAY

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	133.0	6.0				STEEL

Completion Information[1]

No Completion Records currently in GWIC.

[1] - All diameters reported are **inside** diameter of the casing.

Montana Bureau of Mines and Geology
Ground-Water Information Center Site Report
ANACONDA FOREST PRODUCTS

Plot this site on a topographic map

Location Information

GWIC Id: 68163
Location (TRS): 13N 18W 22 BB
County (MT): MISSOULA
DNRC Water Right:
PWS Id:
Block:
Lot:
Addition:

Source of Data: LOG
Latitude (dd): 46.8764
Longitude (dd): -113.8678
Geomethod: TRS-SEC
Datum: NAD27
Altitude (feet):
Certificate of Survey:
Type of Site: WELL

Well Construction and Performance Data

Total Depth (ft): 83.00
Static Water Level (ft): 28.00
Pumping Water Level (ft):
Yield (gpm): 20.00
Test Type:
Test Duration:
Drill Stem Setting (ft):
Recovery Water Level (ft):
Recovery Time (hrs):
Well Notes:

How Drilled:
Driller's Name:
Driller License:
Completion Date (m/d/y): 10/10/1958
Special Conditions:
Is Well Flowing?:
Shut-In Pressure:
Geology/Aquifer: 112ALVM
Well/Water Use: INDUSTRIAL

Hole Diameter Information

No Hole Diameter Records currently in GWIC.

Annular Seal Information

No Seal Records currently in GWIC.

Casing Information[1]

From	To	Dia	Wall Thickness	Pressure Rating	Joint	Type
0.0	82.5	8.0				STEEL

Completion Information[1]

No Completion Records currently in GWIC.

Lithology Information

From	To	Description
0.0	12.0	GRAVEL BOULDERS
12.0	17.0	GRAVEL BOULDERS W/CLAY
17.0	44.0	SMALLER GRAVEL CLAY
44.0	54.0	HEAVING SAND FAIR SIZED GRAVEL WATER
54.0	60.0	SAND WATER
65.0	70.0	GRAVEL SAND WATER
70.0	72.0	CLAY GRAVEL
72.0	80.0	GRAVEL SAND WATER
80.0	82.0	ROCK

1 - All diameters reported are **inside** diameter of the casing.

APPENDIX B

HEALTH AND SAFETY PLAN

Olympus Technical Services, Inc.

SITE HEALTH AND SAFETY PLAN

THIS HEALTH AND SAFETY PLAN IS TO BE USED IN CONJUNCTION WITH
OLYMPUS' CORPORATE HEALTH AND SAFETY PLAN
(To be completed by the Project Manager and the Site Health and Safety Officer.)

DATE OF COMPLETION 3/27/2006 OLYMPUS PROJECT # A1534

EMERGENCY INFORMATION (Attach map to nearest hospital)

Emergency Numbers

Fire 911 Ambulance 911 Hospital 911

Olympus Office 406/443-3087 Client Number 406/841-5039

Project Manager Alan Stine Olympus Contact Alan Stine

Site Health and Safety Officer Alan Stine

Client Contact Kieth Large

Site Address Stimson Lumber Company, Section 22, Township 13 North, Range 18 West

Location of Health and Safety Equipment In vehicle

SITE DESCRIPTION (Include location, area affected, topography, access, site control, boundaries & site map)

Stimson cooling pond. The pond is located along the south bank of the Blackfoot River. A levee separates the pond from the river and provides an access road around the pond. The pond collects boiler blowdown water and runoff water from the mill yard.

PROJECT PLAN (Include job tasks, hazardous substance information forms(s), & equipment being used on/near site)

Collect sediment samples from the pond using a core drill rig mounted on a barge. Hazardous substances have not been identified at the site but may be present.

SITE HEALTH AND SAFETY MEETING CHECK LIST

DATE 3/21/06 OLYMPUS PROJECT # A1534

HAZARD EVALUATION (See attachment A for assistance)

Substance	Concentration	Skin: Low	Skin: Moderate	Skin: High	Skin: Extreme	Inhalation: Low	Inhalation: Moderate	Inhalation: High	Inhalation: Extreme	Ingestion: Low	Ingestion: Moderate	Ingestion: High	Ingestion: Extreme
Unknown		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Exposure Hazard(s) (For PPE Purposes)

Other Hazards Slip, trip, and fall hazards. Hazards associated with working over water.

FIRE/EXPLOSION HAZARDS

Flash Point ☐ Dangerous - 100 F or Less LEL________

☐ Moderate - 100 F to 200 F UEL________

☐ Low - 200 F or Above Other________

POSSIBLE HAZARDOUS REACTIONS

Stable ☐ Unstable ☐ Pyroforic ☐ Oxidizer ☐ Water ☐ Hazardous Polymerization ☐ Toxic Gas Generation ☐

Reaction Results From________

Type of Decomposition________ Decomposes To________

PPE PROTECTION

Job Tasks	Level of Protection
All tasks	Level D, latex or nitril sample gloves
	Life jackets when working over water

DECONTAMINATION/PPE DISPOSAL Dry decon if possible, otherwise wash and rinse. Containerization of all PPE and decontamination liquids.

AIR MONITORING

YES ☒ NO ☐ To Be Done By: PID

(A) On entry before job begins YES ☒ NO ☐ (B) During time in hazardous waste location YES ☒ NO ☐

If "YES" - Time Interval During sample collection

ELECTRICAL HAZARDS GFCI required for all electrical equipment

COMMENTS While no hazardous substances have been identified, they may be present. Be aware of potential for hazardous substances during sample collection and avoid direct contact.

ATTACHMENT A

References - for Hazard Evaluation

Chemical Hazard Response Information System (C.H.R.I.S.), U.S. Department of Transportation and U.S. Coast Guard.

Dangerous Properties of Industrial Materials, Sax and Lewis.

NIOSH Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services.

Definitions - for Exposure Hazard(s)

Low - Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given.

Moderate - Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.

High - Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment were given.

Extreme - Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment were given.

SITE HEALTH AND SAFETY MEETING CHECK LIST

Date:______________________________ Job Number:______________________________
Project Name:____
Field Location:____
Site Manager:________________________ Health & Safety Coordinator:__________________

Introduction of People ---------------- ( )
Work Scope ---------------------------- ( )
Level of Entry -------------------------- ( )
PPE to be Used ---------------------- ( )
Identify Hazards ---------------------- ( )
Equipment Being Used ------------- ( )
Site Specific Safety Rules ---------- ( )

Emergency Information

Telephone Numbers ---------------- ( )
Telephone Location ----------------- ( )
Hospital Directions/Map ----------- ( )
Escape Route ----------------------- ( )
Fire Extinguisher -------------------- ( )
First Aid Kit ---------------------------- ( )
Eyewash -------------------------------- ( )

General

Restrooms ---------------------------- ( )
Work Zones Delineated ------------ ( )
Decon/Demob Requirements ---- ( )
Onsite Personnel meet HSAM
Requirements for Medical,
Fit Test, & Training -------- ( )
Personnel have read Site Health
& Safety Plan --------------- ( )
Communication Procedures ------ ( )

If Applicable

MSDS Onsite/Available ------------- ( )
Fit Testing ----------------------------- ( )
Confined Entry Permit ------------- ( )
Monitoring Equipment
Calibrated ----------------- ( )

Personnel Present

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Comments

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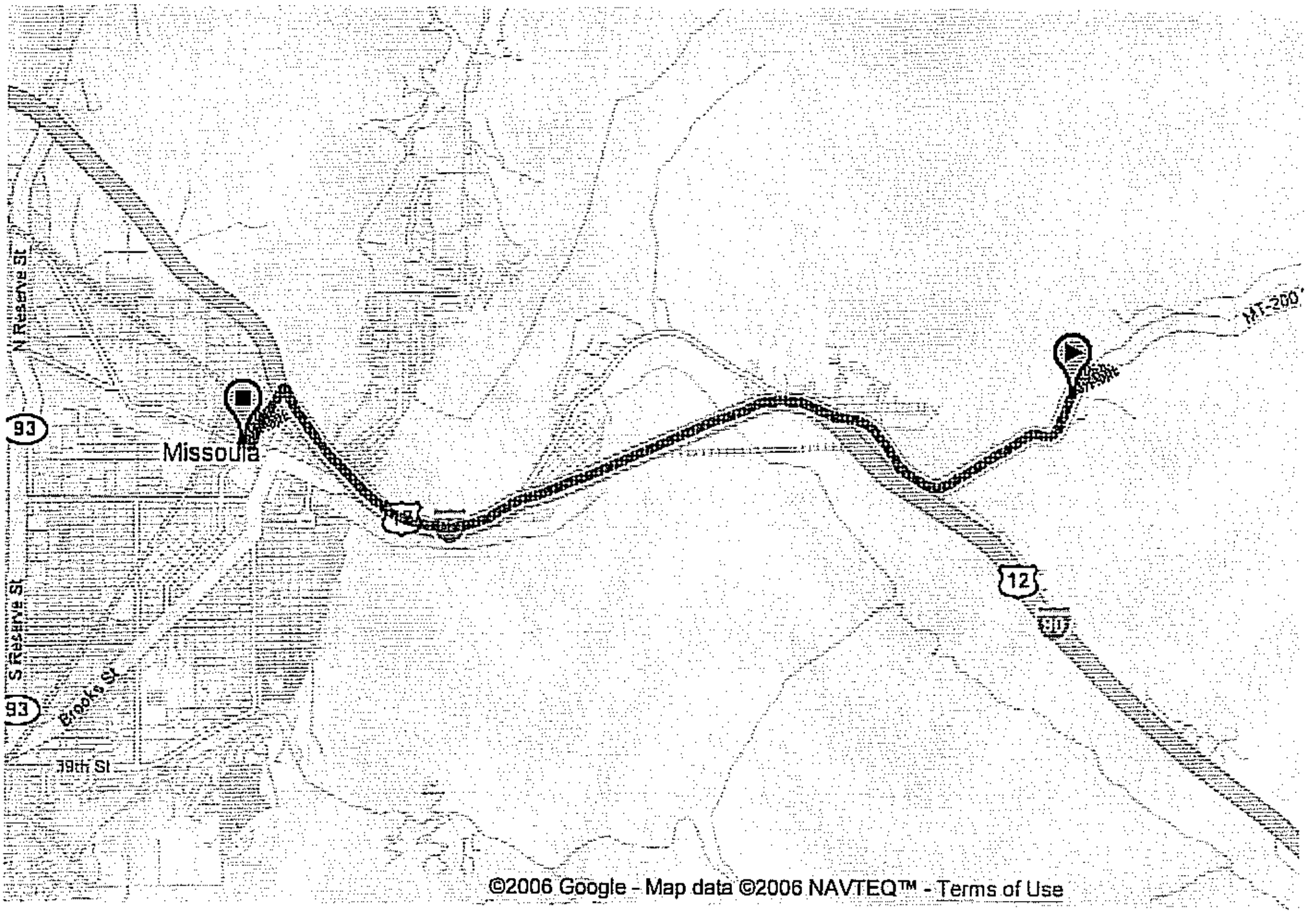
Google Maps

Start **11000 Mt Highway 200 E**
Bonner, MT 59823

End **500 W Broadway St**
Missoula, MT 59802

Travel **8.6 mi (about 11 mins)**



Directions

1.	Head **southwest** from **MT-200**	**2.3 mi** 3 mins
← 2.	Bear **left**	**0.1 mi**
3.	Take the **I-90 W** ramp	**5.3 mi** 5 mins
4.	Take the **Orange St** exit **104**	**0.2 mi**
← 5.	Turn **left** at **N Orange St**	**0.6 mi** 1 min
→ 6.	Turn **right** at **W Broadway St**	**477 ft**
7.	Arrive at 500 W Broadway St Missoula, MT 59802	

These directions are for planning purposes only. You may find that construction projects, traffic, or other events may cause road conditions to differ from the map results.

APPENDIX C

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE G-1

FIELD LOGBOOK/PHOTOGRAPHS

Standard Operating Procedure
Field Logbook/Photographs (G-1)

Field Logbook

A separate field logbook will be used for each field task. Each logbook shall have a unique document control number. The logbooks will be bound and have consecutively numbered pages. The information recorded in these logbooks shall be written in indelible ink. The author will initial and date entries at the end of each day and a line shall be drawn through the remainder of the page. All corrections will consist of a single line-out deletion in indelible ink, followed by the author's initials and the date. No bound field logbooks will be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document. These bound logbooks, at a minimum, shall include the following entries:

1. A purpose and description of the proposed field task,
2. Time and date fieldwork started,
3. Location and description of the work area, including sketches if possible, map references and photographs, and sketches of well construction details, soils, pits, etc.,
4. Names and titles of field personnel,
5. Name, address and phone number of any field contacts,
6. Meteorological conditions at the beginning of fieldwork and any ensuing changes in these conditions,
7. Details of the fieldwork performed and field data sheets used (including document control numbers), with special attention to any deviations from the task-specific Sampling and Analysis Plan (SAP) or Standard Operating Procedures(SOPs),
8. All field measurements made,
9. Any field laboratory analytical results, and
10. Personnel and equipment decontamination procedures.

For any field sampling work, at a minimum, the following entries should be made:

1. Sample location and number,
2. Sample type (e.g., ground water) and amount collected,
3. Date and time of sample collection,
4. Split samples taken by other parties. Note the type of sample, sample location, time/date, name of person, person's company, any other pertinent information,
5. Sampling method, particularly and deviations from the SOP,
6. Suspected waste composition, including an estimate of the hazard level as being low or medium,
7. Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample (e.g., filters and preserving reagents), and
8. Sample preservation, handling, packaging, labeling, shipping information (e.g., weight), the shipping agent, and the laboratory where the samples will be sent.

After each day of fieldwork, all the bound logbooks will be locked up in a location accessible to the Quality Assurance Manager, such as the field office filing cabinet.

Photographs

Photographs will be taken of field activities using a camera-lens system with a perspective similar to the naked eye. Photographs should include a measured scale in the picture, when practical. Telephoto or wide-angle shots will not be used, since they cannot be used in enforcement meetings. The following items shall be recorded in the bound field logbook for each photograph taken:

1. The photographer's name, the date, the time of the photography and the general direction faced,
2. A brief description of the subject and the fieldwork portrayed in the picture, and
3. Sequential number of the photograph and the roll number on which it is contained.

PHOTOGRAPH LABELS

PHOTOGRAPH NUMBER:____________________
DATE:_____________________________________
TIME:_____________________________________
DIRECTION:________________________________
PHOTOGRAPHER:____________________________
DESCRIPTION:______________________________
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STANDARD OPERATING PROCEDURE G-2

SAMPLE PACKAGING AND SHIPPING

Standard Operating Procedure
Sample Packaging and Shipping (G-2)

The following steps shall be followed when packaging and shipping environmental samples:

1. Collect the sample as stated in appropriate standard operating procedure (SOP).
2. Wipe the exterior of the sample container with appropriate decontamination solution while wearing the necessary personal protective equipment as specified in the site-specific Health and Safety Plan.
3. Attach the identification tag to the sample container. Place sample container in a 2-ml thick (or thicker) zip-lock polyethylene bag, one sample per bag. Position the sample container so the identification tag can be read through the bag, then seal the bag.
4. Place one or more bagged samples into a strong outside water-tight container, such as an ice chest or a DOT-approved fiberboard box.
5. Add ice and/or blue ice if required by the appropriate SOP.
6. Secure containers with noncombustible, absorbent, cushioning materials.
7. Secure the properly completed chain-of-custody form (see SOP G-4) to the inside of the ice chest lid in a plastic bag. The chain-of-custody form shall list only those samples contained in the ice chest.
8. Tape ice chest drain and ice chest closed using fiberglass tape and seal with several chain-of-custody seals.
9. Complete the air bill and Shipper's Certification for Restricted Articles/Dangerous Goods if required.
10. Label and address the ice chest.

Note: Bagging of samples and lining of coolers will not be necessary if samplers transport samples directly to the laboratory.

STANDARD OPERATING PROCEDURE G-3

FIELD QUALITY CONTROL SAMPLES

Standard Operating Procedure
Field Quality Control Samples (G-3)

Field Quality Control (QC) is a part of the project Quality Assurance/Quality Control program and is described in detail in the project specific Quality Assurance Plan. This Standard Operating Procedure (SOP) describes the purpose, preparation and collection frequency of field QC blanks and duplicate samples for aqueous matrices. QC samples will not be collected for soil samples because solid media is too heterogeneous. Table G-3.1 summarizes the field QC sampling requirements described in this SOP.

At least one set of field QC samples will be prepared for each sampling event. An event is defined by any of the following conditions:

1. The beginning of a new sampling round,
2. A significant change in either the sample type, matrix, or location, or
3. A change in any sample analysis parameter.

If the number of field QC samples taken does not equal to an integer multiple of the interval specified in Table G-3.1, use the next higher multiple. For example, if a frequency of 1 in 20 is indicated and 28 field samples are collected, then two field QC samples will be prepared.

All field QC samples shall be packaged and shipped with field samples to the laboratory in accordance to procedures outlined in SOP-G-2. Sample custody will be maintained according to procedures outlined in SOP-G-4. The text below describes the field QC samples for the aqueous matrix.

Field QC Samples

Trip Blank

A trip blank will be used to help identify cross contamination in a shipment of aqueous samples for analyzing volatile organic compounds (VOCs) only. Trip blanks will be prepared by the appropriate laboratory and in the appropriate containers using distilled/deionized (DS/DI) water. Trip blanks will be transported unopened to and from the field with field samples. One trip blank will be prepared for and sent with each shipment of samples for analyzing VOCs.

Equipment Rinsate Blank

Equipment rinsate blanks will be used to help identify possible contamination from the sampling environment or from sampling equipment, such as a bailer, collection container, or filter apparatus. Equipment rinsate blanks for field-filtered samples will be prepared by processing a representative amount of DS/DI water through the decontaminated sample collection equipment and filtering apparatus with a filter, then transferring the water to an appropriate sample container, and adding any necessary preservatives.

Equipment rinsate blanks for non-field filtered samples will be prepared by processing a representative amount of laboratory DS/DI water through the decontaminated sample collection equipment, then transferring the water to an appropriate sample container, and adding any necessary preservatives. Equipment rinsate blanks are required for all inorganic or organic constituents. Equipment rinsate blanks will be prepared daily, or once for every 20 samples collected, whichever is more frequent.

Field Blank

Field blanks provide a measure of various cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. A field blank is prepared by the same protocols as a normal sample, but is not exposed to any sampling equipment. A field blank is prepared in the field and consists of a representative amount of DS/DI and/or reagent-grade (analyte-free) water and any necessary preservatives. A field blank is contained in a sample bottle randomly chosen from each lot of bottles received from the supplier. Field blanks are required for all inorganic or organic constituents. Field blanks will be collected for each type of sample bottle at a frequency of 1 per 20 samples or once per sampling event, whichever is more frequent.

Field Duplicate

Field duplicates are co-located samples collected identically and consecutively over a minimum period of time and provide a measure of the total analytical bias (field and laboratory variance), including bias resulting from the heterogeneity of the replicate sample set itself. Field duplicates consist of two samples (one sample and one replicate) collected consecutively at the same location and placed in different bottles for separate analysis. Each duplicate will have its own sample number. The two samples will be sent to the laboratory and analyzed for identical chemical parameters. Field duplicate samples will be collected at a minimum frequency of 1 per 20 samples or once per sampling event, whichever is more frequent.

TABLE G-3.1
FIELD QC SAMPLING REQUIREMENTS

QC Sample	Sample Matrix	Sample Location	Preparation Method	Laboratory Frequency
Equipment Rinsate Blank	Aqueous	Field	DI/DS water through sampling equipment and preserved.	Daily or one every 20 samples.
Field Blank	Aqueous	Field	DI/DS water not exposed to sampling equipment.	One per sampling event or one every 20 samples.
Field Duplicate	Aqueous and Solid	Field	Co-located samples collected identically and consecutively.	One per sampling event or one per 20 samples.
Trip Blanks	Aqueous (VOCs only)	Laboratory	DI/DS Water	One per sample shipment.

STANDARD OPERATING PROCEDURE G-4

SAMPLE CUSTODY

Standard Operating Procedure
Sample Custody (G-4)

A stringent, established program of sample chain-of-custody procedures shall be followed during field sample collection and handling activities to account for each sample. Preprinted labels will be used to maintain the highest degree of control in sample handling. The preprinted labels(with spaces provided) will ensure that all necessary information is retained with the sample chain-of-custody records, and shipping manifest will be utilized to maintain control over access to the sample destination after shipment from the sample collection site.

SAMPLE CONTROL FORMS

Sample Label

Each sample collected at the site shall be identified with a sample label. The following information shall be recorded on the label:

1. Project number,
2. Sample type (grab or composite, media sampled),
3. Sample identification (well number for groundwater samples, soil boring number, sample number, and sample depth for soil samples, etc.),
4. Date and time sample was taken,
5. Sampler's name,
6. Sample tag number (a unique serial number stamped or written on each sample label; duplicates and blanks shall be assigned separate sample numbers),
7. Preservative added, and
8. Remarks, including pertinent field observations.

Chain of Custody Record

Chain-of-custody records ensure that samples are traceable from the time of collection until introduced as evidence in legal proceedings. A sample is in a person's custody if any of the following criteria are met:

1. The sample is in the person's possession.
2. The sample is in the person's view after being in possession.
3. The sample has been locked up to prevent tampering after it was in the person's possession.
4. The sample was in the person's possession, then was transferred to a designated secure area.

The chain-of-custody record is completed in the field by the individual physically in charge of the sample collection. The chain-of-custody record may be completed concurrently with the field sample data sheet or before shipping samples to the laboratory. The sampler is personally responsible for the care and custody of the sample until it is shipped.

When transferring the sample possession, the individuals relinquishing and receiving the sample will sign, date, and write the time of day on the chain-of-custody record. The chain-of-custody record is enclosed with the sample after it has been signed by the sampler.

The chain-of-custody record also serves as the laboratory request form. As shown on the attached sample chain-of-custody form, a space is included on the form to list the analyses requested for each set of samples.

Field sample data is to be recorded in the field notebook. The field data correlates the assigned sample bottle designation to a specific well or sample location, or to other distinguishing features or attributes (i.e., dummy sample, duplicate sample, sample blank, etc.).

STANDARD OPERATING PROCEDURE G-5

SOIL AND WATER SAMPLING FIELD EQUIPMENT DECONTAMINATION

Standard Operating Procedure
Soil and Water Sampling Field Equipment Decontamination (G-5)

To prevent potential cross-contamination of samples, all reusable soil and water sampling equipment and pumps shall be decontaminated. The sample personnel shall set up the area used to decontaminate soil and water sampling equipment in the manner shown on Figure G-5-1. This area will be located upwind from the specific sampling area. The personnel performing the decontamination procedures will wear protective clothing as specified in the site-specific Health and Safety Plan.

PROCEDURES USED TO DECONTAMINATE INORGANICALLY CONTAMINATED SOIL SAMPLING EQUIPMENT

Table G-5.1 lists the equipment that shall be used to decontaminate the soil sampling equipment and the decontamination station where it will be used. The specific procedures for decontaminating inorganic contaminated soil sampling equipment include the following:

1. At Station No. 1, first wash the contaminated equipment in a tub containing tap water to remove the soil material. Follow with a second wash in a tub containing water mixed with a detergent, such as Alconox.
2. Move the equipment to the wash tub in Station No. 2. Rinse the equipment with clean water, wash with 0.1 Normal nitric acid (HNO_3), then rinse with distilled/deionized (DS/DI) water.
3. At Station No. 3, place the clean equipment on plastic sheeting until it is used again.

   After decontaminating all the soil sampling equipment, the disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in a trash collection facility. The wash and rise water from Station Nos. 1 and 2 will be disposed in accordance with the site-specific SAP. At the end of each day, all soil sampling equipment shall be stored in large plastic bags.

PROCEDURES USED TO DECONTAMINATE INORGANICALLY CONTAMINATED WATER SAMPLING EQUIPMENT

Table G-5.2 lists the equipment that shall be used to decontaminate the water sampling equipment and the decontamination stations where it will be used. (To decontaminate pumps, see section **Decontamination of Sampling Pumps** at the end of this SOP).

The specific procedures for decontaminating inorganic contaminated water sampling equipment include the following:

1. At Station No. 1, wash the contaminated equipment in a tub containing water mixed with a detergent such as Alconox.
2. Move the equipment to the wash tub in Station No. 2. First, rinse the equipment with DS/DI water. Then rinse the equipment with dilute (0.1 Normal) nitric acid and follow with a second rinse using DS/DI water.
3. At Station No.3, place the clean equipment on plastic sheeting until it is used again.

After decontaminating all the water sampling equipment, the disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in a trash collection facility. The wash and rinse water from Station No. 1 and No. 2 will be disposed in accordance with the site-specific SAP. At the end of each day, all water sampling equipment shall be stored in large plastic bags.

PROCEDURES USED TO DECONTAMINATE ORGANICALLY CONTAMINATED SOIL SAMPLING EQUIPMENT

Table G-5.3 lists the equipment and supplies that shall be used to decontaminate the soil sampling equipment and the decontamination station where it will be used. The specific procedures for decontaminating the organic contaminated soil sampling equipment include the following:

1. At Station No. 1, Tub No. 1, wash and scrub with a detergent such as Alconox, or use a pressurized steam cleaner to remove the soil material. Collect the waste water for disposal in accordance with the site-specific SAP.
2. At Station No. 1, Tub No. 2, double rinse the equipment with DS/DI water.
3. At Station No. 2, rinse the equipment with methanol followed by a double rinse with DS/DI water.
4. At Station No. 3, lay the equipment on the clean plastic to air dry.
5. Wrap the equipment in clean plastic until reuse.

The disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in the trash collection containers. The wash and rinse waters from Stations No. 1 and 2 will be disposed in accordance with the site-specific SAP.

PROCEDURES USED TO DECONTAMINATE ORGANICALLY CONTAMINATED WATER SAMPLING EQUIPMENT

Table G-5.4 lists the equipment and supplies that shall be used to decontaminate the water sampling equipment and the decontamination station where it will be used. (To decontaminate pumps, see section **Decontamination of Sampling Pumps** at the end of this SOP.)

The specific procedures for decontaminating the organic contaminated water sampling equipment include the following:

1. At Station No. 1, Tub No. 1, wash and scrub the equipment with a detergent such as Alconox, or use a pressurized steam cleaner to remove the soil material. Collect the waste water for disposal in accordance with the site-specific SAP.
2. At Station No. 1, Tub No. 2, double rinse the equipment with DS/DI water.
3. At Station No. 2, rinse the equipment with methanol followed by a double rinse with DS/DI water.
4. At Station No. 3, lay the equipment out on the clean plastic to air dry.
5. Wrap the equipment in the clean plastic until reuse.

The disposable gloves and used plastic from Station No. 3 shall be placed in garbage bags and disposed in the trash collection containers. The wash and rinse waters from Stations No. 1 and 2 will be disposed in accordance with the site-specific SAP.

DECONTAMINATION OF SAMPLING PUMPS

When using field decontamination, it is advisable to begin sampling with the well containing the lowest anticipated analyte concentration. Successive samples should be obtained from wells anticipated to have increasing analyte concentrations. Use of dedicated pump equipment is preferable when feasible. Table G-5.5 lists the decontamination equipment required.

When pumps (e.g., submersible or bladder) are submerged below the water surface to collect water samples, they should be cleaned and flushed between uses. This cleaning process consists of an external detergent wash and high-pressure tap water rinse, or steam cleaning, of pump casing, tubing and cables, followed by a flush of potable water through the pump. This flushing can be accomplished by pouring clean tap water from a carboy into the end of the discharge tube and working it down to the inside of the pump. The procedure should be repeated; then the tubing and inside of the pump should be rinsed with DS/DI water.

Surface pumps (e.g., peristaltic or diaphragm) used for well evacuation need not be cleaned between well locations. However, a new length of polyethylene tubing must be used for each well and discarded after use. The pump and hose should always be placed on clean polyethylene sheeting to avoid contact with the ground surface.

TABLE G-5.1

DECONTAMINATION EQUIPMENT FOR INORGANICALLY CONTAMINATED SOIL SAMPLING EQUIPMENT

Equipment List for Decontamination

Item	Quantity
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
0.1 Normal Nitric Acid	a
Hard-bristle brushes	2
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1
- Alconox
- Tap water
- Two 3-gallon plastic washtubs
- Scrub brush
- DS/DI water

Station No. 2
- 3-gallon plastic washtub
- DS/DI water
- 0.1 Normal Nitric Acid

Station No. 3
- Plastic sheeting or garbage bag

---

a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-5.2

DECONTAMINATION EQUIPMENT FOR INORGANICALLY CONTAMINATED WATER SAMPLING EQUIPMENT

Equipment List for Decontamination

Item	Quantity
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
0.1 Normal Nitric Acid	a
Hard-bristle brushes	2
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1
- Alconox
- Tap water
- Two 3-gallon plastic washtubs
- Scrub brush
- DS/DI water

Station No. 2
- 3-gallon plastic washtub
- DS/DI water
- 0.1 Normal Nitric Acid

Station No. 3
- Plastic sheeting or garbage bag

---

a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-5.3

DECONTAMINATION EQUIPMENT FOR ORGANICALLY CONTAMINATED SOIL SAMPLING EQUIPMENT

Equipment List for Decontamination

Item	Quantity
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
Hard-bristle brushes	2
Methanol	a
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1
- Alconox
- Tap water
- Two 3-gallon plastic washtubs
- Scrub brush
- DS/DI water

Station No. 2
- 3-gallon plastic washtub
- Methanol and DS/DI water

Station No. 3
- Plastic sheeting or garbage bag

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a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-5.4

DECONTAMINATION EQUIPMENT FOR ORGANICALLY CONTAMINATED WATER SAMPLING EQUIPMENT

Equipment List for Decontamination

Item	Quantity
3-gallon plastic tubs	3
5-gallon plastic container, tap water	a
5-gallon carboy, DS/DI water	a
Alconox	a
Hard-bristle brushes	2
Methanol	a
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
Kimwipes	a
55-gallon drum(s)	a
Drum labels	a
Spray paint	a

Equipment at Decontamination Stations

Station No. 1
- Alconox
- Tap water
- Two 3-gallon plastic washtubs
- Scrub brush
- Acetone and methylene chloride or hexane

Station No. 2
- 3-gallon plastic washtub
- Methanol and DS/DI water

Station No. 3
- Plastic sheeting or garbage bag

---

a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

b Type of protective equipment as specified in the site-specific Health and Safety Plan.

TABLE G-5.5

DECONTAMINATION EQUIPMENT FOR SAMPLING PUMPS
EQUIPMENT LIST FOR DECONTAMINATION OF SUBMERSIBLE PUMPS

Equipment List for Decontamination of Submersible Pumps

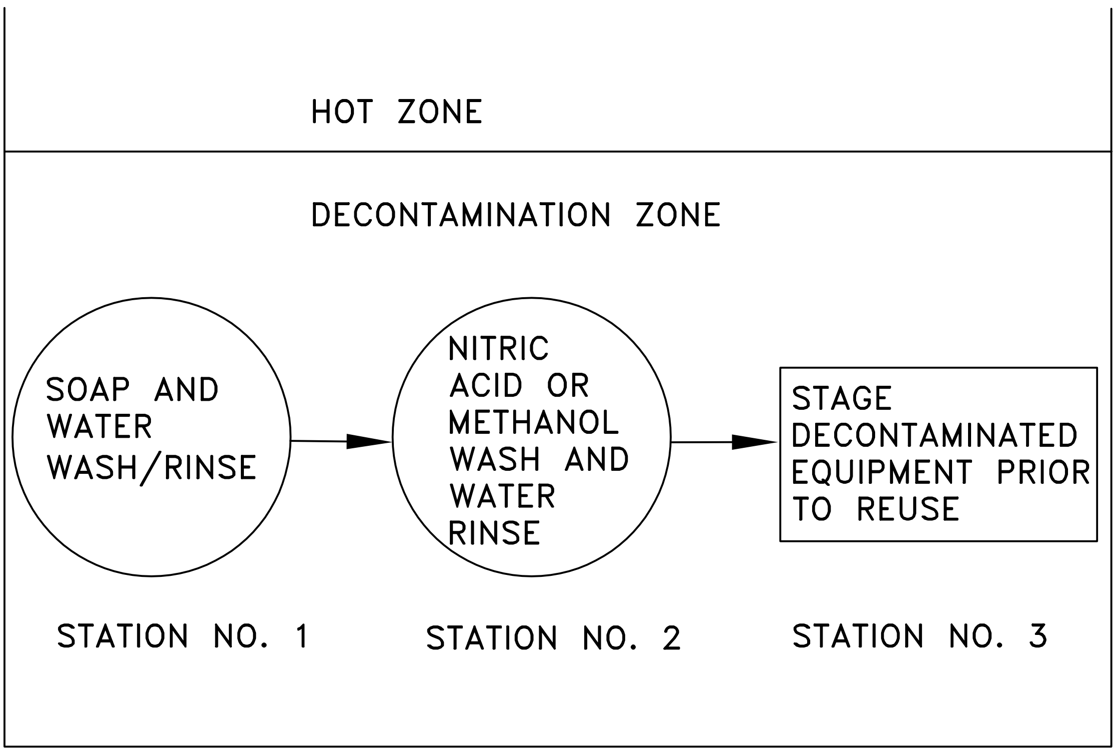
Item	Quantity
Alconox	a
Tap water	a
Hard-bristle brushes	1
Plastic sheeting or garbage bags	a
Personal protective equipment	a,b
30-gallon plastic trash can or plastic overpack drum	1
55-gallon drum(s)	a
Drum labels	a
Steam cleaner	Optional

Equipment List for Decontamination of Surface Pumps

Item	Quanity
Polyethylene tubing	a
Plastic sheeting or garbage bags	a

a Quantity depends on the size of the sampling effort and is, therefore, left to the discretion of the field hydrogeologist or geologist.

b Type of protective equipment as specified in the site-specific Health and Safety Plan.



Olympus Technical Services, Inc.

DECONTAMINATION STATIONS SETUP
SOP G-5 SOIL AND WATER SAMPLING
FIELD EQUIPMENT DECONTAMINATION

FIGURE G-5-1

Drawn: RSA	Checked: CRS	Date: 5/25/99	Job No:
Design:	Approved:	Scale:	File: sop.dwg

STANDARD OPERATING PROCEDURE SS-1

SAMPLE COLLECTION FROM SOIL BORINGS, EXCAVATIONS AND HAND-DUG PITS

STANDARD OPERATING PROCEDURE SS-1
SAMPLE COLLECTION FROM SOIL BORINGS, EXCAVATIONS, AND HAND DUG PITS

SOIL BORING PROCEDURES

The following procedures are designed to be used during the operation of auger type drill rigs during soil sampling operations. The procedures listed below may be modified in the field by the agreement of the lead site sampler and drill operators based on field and site conditions after appropriate annotations have been made in the appropriate bound field logbook. **Prior to any subsurface work, have utilities (gas and electric, telephone, sewer, etc.) located by a regional one-call service or the utility companies as needed.**

1. Locate the site as directed in the site-specific Sampling and Analysis Plan (SAP).

2. Drillers prepare rig for operation. This includes; but is not limited to, decontamination of the drill rig tools and sampling equipment, leveling the rig, preparing the downhole tool, preparing the auger "flights", and establishing the drill over the location.

3. Mount the split tube to the drive stem.

4. Prior to using the split spoon sampler, sample the surface increment to a depth in accordance with the site-specific SAP.

5. Place split spoon sampler on the ground surface and advance sampler to the desired depth using the rig hammer.

6. After driving the split spoon sampler its entire length or upon refusal of advancement, recover the split spoon sampler. Refusal is defined as 100 blows with the rig hammer and less than 6 inches advancement of the split spoon sampler. Less than 100 blows may be defined as refusal if there is no split spoon advancement. This decision will be made at the discretion of the field sampler.

7. After recovery of the split spoon sampler, open the spoon and place the spoon containing the soil sample into a holding device, maintaining the intervals as sampled.

8. Sampling personnel will then describe the soil sample based on the site-specific SAP instructions, and fill out the appropriate bound file logbooks, field profile sheets, field site sheets, and quality assurance/quality control documentation.

9. Decontaminate the split spoon sampler.

10. Repeat steps 3 to 9 until sampling is completed.

11. The drill rig tools and sampling equipment will be decontaminated prior to moving onto the next site. The drill rig will be left in a safe and secure fashion at the end of each shift.

BACKHOE PIT EXCAVATIONS

The following procedures are designed to be used during the operation of backhoe equipment to excavate sites prior to soil sampling operations. The procedures listed below may be modified in the field by the agreement of the lead site sampler and backhoe operators based on field and site conditions after appropriate annotations have been made in the appropriate bound field logbook.

1. Locate the site as directed in the site-specific SAP. Identify locations of underground utilities.

2. Place the backhoe tractor in a safe position. This will be based on the operators judgment and site conditions.

3. Begin backhoe excavation. Place excavated materials a sufficient distance from the excavation to prevent the return of excavated materials to the pit. Topsoil will be determined by the technical field support, removed, and segregated from the underlying soils.

4. Continue excavation of the pit to the required depth. This depth shall not exceed 5 feet from the ground surface unless the proper pit exit trenches, shoring, and sloping excavations have been excavated to prevent accidental burials of sampling crew and to meet or exceed all OSHA Construction Standards (29 CFR 1926; Appendix A) for entrance by sampling personnel. If OSHA Construction standards for entrance cannot be met, the sample will be obtained from the backhoe bucket.

5. Sampling personnel may enter the pit after all excavation is complete and the excavation is deemed safe to occupy. The site safety officer shall be the oversight authority and will determine what is safe and what is not safe. "Safe" for backhoe pit excavations is defined as meeting or exceeding all OSHA Construction Standards (29 CFR 1926; Appendix A), for entrance by sampling personnel.

6. Soil profile descriptions shall be made from a hand cleaned surface along the pit wall using the Unified Soil Classification System.

7. Soil sampling will follow soil profile description and establishment of sampling intervals based on the site-specific SAP. Soil samples will be collected with decontaminated stainless steel or plastic sampling tools and bowls from the appropriate intervals. A sample collected from a depth increment shall be a representative composite of the entire interval and not biased by sample mass collected largely from the top or bottom of the increment.

8. All pertinent field quality assurance/quality control documentation, bound field logbooks, sample labels, profile sheets, and field site sheets shall be completed prior to refilling the pit.

9. After items 1 through 8 have been completed to the satisfaction of the lead sampler, the site pit shall be refilled with the previously excavated materials. The earthen materials are to be replaced in the same order they were excavated with topsoil placed on top of the filled pit. There will be some unavoidable mixing of soil during the excavation.

10. Decontaminate all sampling equipment, including the backhoe bucket.

11. Move to the next site. If the previous site was the last site of the day, decontaminate the backhoe bucket, secure, and park the backhoe tractor rig for the evening.

HAND DUG PITS

The following procedures are designed to be used during the operation of hand tools to excavate sites prior to soil sampling operations. The procedures listed below may be modified in the field by the agreement of the lead site sampler and field personnel based on field and site conditions after appropriate annotations have been made in the appropriate bound field logbook.

1. Locate the site as directed in the site-specific SAP.

2. Select the appropriate orientation for the excavation. This is be based on the lead field sampler's judgment and site conditions.

3. Begin pit excavation. Place excavated materials a sufficient distance from the excavation to prevent the return of excavated materials to the pit. Topsoil is to be placed separately from the underlying soils. Placement of excavated materials on a sheet of plastic is recommended to facilitate returning excavated material to the pit.

4. Continue excavation of the pit to the required depth. This depth shall not exceed 24 inches from the ground surface.

5. Soil profile descriptions shall be made from a hand cleaned surface along the pit wall using the Unified Soil Classification System.

6. Soil sampling will follow soil profile description and establishment of sampling intervals based on the site-specific SAP. Soil samples will be collected with decontaminated stainless steel or plastic sampling tools and bowls from the appropriate intervals. A sample collected from a depth increment shall be representative composite of the entire interval and not biased by sample mass collected largely from the top or bottom of the increment.

7. All pertinent field quality assurance/quality control documentation, bound field logbooks, sample labels, profile sheets, and field site sheets shall be completed prior to refilling the pit.

8. After items 1 through 7 have been completed to the satisfaction of the lead sampler, the site pit shall be refilled with the previously excavated materials. The earthen materials are to be replaced in the same order they were excavated with

topsoil placed on top of the filled pit. There will be some unavoidable mixing of the soil during the excavation.

9. Decontaminate all sampling equipment.

10. Move to the next site. If the previous site was the last site of the day, decontaminate the field sampling equipment, secure all equipment, and exit the site.

ATTACHMENT TO SOP SS-1
29 CFR 1926 SUBPART P - EXCAVATION,
TRENCHING AND SHORING

Labor

29

PART 1926

Revised as of July 1, 1990

CONTAINING
A CODIFICATION OF DOCUMENTS
OF GENERAL APPLICABILITY
AND FUTURE EFFECT

AS OF JULY 1, 1990

With Ancillaries

Published by
the Office of the Federal Register
National Archives and Records
Administration

as a Special Edition of
the Federal Register

Subpart P—Excavations

AUTHORITY: Sec. 107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable, and 29 CFR part 1911.

SOURCE: 54 FR 45959, Oct. 31, 1989, unless otherwise noted.

§ 1926.650 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(b) *Definitions applicable to this subpart.*

Accepted engineering practices means those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed, specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system) means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or *sides* means the vertical or inclined earth surfaces formed as a result of excavation work.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickout means the accidental release or failure of a cross brace.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with § 1926.652 (c)(3) or (c)(4). Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides. See "Faces."

Sloping (Sloping system) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp means a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box. See "Shield."

Trench shield. See "Shield."

Uprights means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

§ 1926.651 General requirements.

(a) *Surface encumbrances.* All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

(b) *Underground installations.* (1) The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

(3) When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.

(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

(c) *Access and egress*—(1) *Structural ramps.* (i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(iii) Structural members used for ramps and runways shall be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

(2) *Means of egress from trench excavations.* A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(d) *Exposure to vehicular traffic.* Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) *Exposure to falling loads.* No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with § 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.

(f) *Warning system for mobile equipment.* When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) *Hazardous atmospheres*—(1) *Testing and controls.* In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50–1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) *Emergency rescue equipment.* (i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

(h) *Protection from hazards associated with water accumulation.* (1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.

(i) *Stability of adjacent structures.* (1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

(j) *Protection of employees from loose rock or soil.* (1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) *Inspections.* (1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) *Fall protection.* (1) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.

(2) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

§ 1926.652 Requirements for protective systems.

(a) *Protection of employees in excavations.* (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 5 feet (1.52m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) *Design of sloping and benching systems.* The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:

(1) *Option (1)—Allowable configurations and slopes.* (i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

(2) *Option (2)—Determination of slopes and configurations using Appendices A and B.* Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and shall include all of the following:

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include at least the following:

(A) The magnitude of the slopes that were determined to be safe for the particular project;

(B) The configurations that were determined to be safe for the particular project; and

(C) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

(c) *Design of support systems, shield systems, and other protective systems.*

Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

(1) *Option (1)—Designs using appendices A, C and D.* Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

(2) *Option (2)—Designs Using Manufacturer's Tabulated Data.* (i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and include all of the following:

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

(d) *Materials and equipment.* (1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued

use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) *Installation and removal of support*—(1) *General.* (i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

(vi) Backfilling shall progress together with the removal of support systems from excavations.

(2) *Additional requirements for support systems for trench excavations.* (i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.

(f) *Sloping and benching systems.* Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

(g) *Shield systems*—(1) *General.* (i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) *Additional requirement for shield systems used in trench excavations.* Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

Appendix A to Subpart P

Soil Classification

(a) *Scope and application*—(1) *Scope.* This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) *Application.* This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in § 1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in

§ 1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) *Definitions.* The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS-121.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil means soil that does not exhibit visible signs of moisture content.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil means soil which is underwater or is free seeping.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or

(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or

(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or

(v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.

(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.

(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

(v) Dry rock that is not stable; or

(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:

(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or

(ii) Granular soils including gravel, sand, and loamy sand; or

(iii) Submerged soil or soil from which water is freely seeping; or

(iv) Submerged rock that is not stable, or

(v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) *Requirements*—(1) *Classification of soil and rock deposits.* Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) *Basis of classification.* The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the America Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) *Visual and manual analyses.* The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) *Layered systems.* In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) *Reclassification.* If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) *Acceptable visual and manual tests.*—(1) *Visual tests.* Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) *Manual tests.* Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) *Plasticity.* Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as ⅛-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of ⅛-inch thread can be held on one end without tearing, the soil is cohesive.

(ii) *Dry strength.* If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) *Thumb penetration.* The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488—"Standard Recommended Practice for Description of Soils (Visual—Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests.* Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

(v) *Drying test.* The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B to Subpart P

Sloping and Benching

(a) *Scope and application.* This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in § 1926.652(b)(2).

(b) *Definitions.*

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements*—(1) *Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least ½ horizontal to one vertical (½H:1V) less steep than the maximum allowable slope.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with § 1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

TABLE B-1

MAXIMUM ALLOWABLE SLOPES

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V)[1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP [3]
STABLE ROCK TYPE A [2] TYPE B TYPE C	VERTICAL (90°) 3/4 : 1 (53°) 1:1 (45°) 1½: 1 (34°)

NOTES:

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
2. A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°)
3. Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

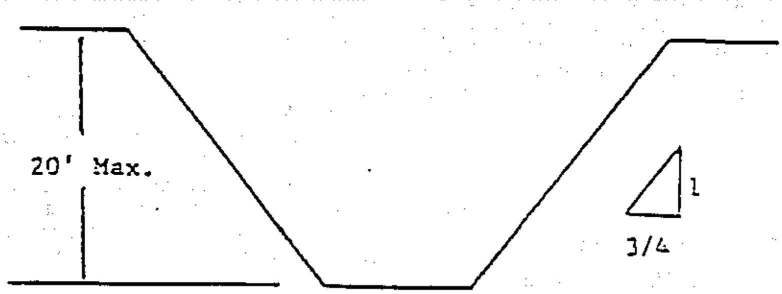
Figure B-1

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

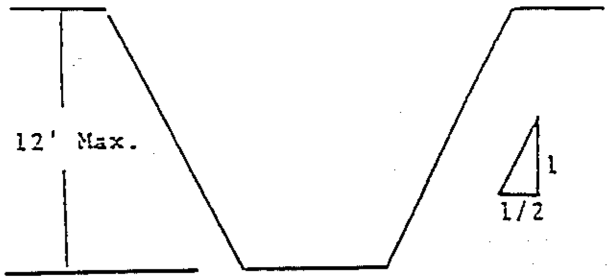
B-1.1 Excavations made in Type A soil

1. All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of ¾:1.



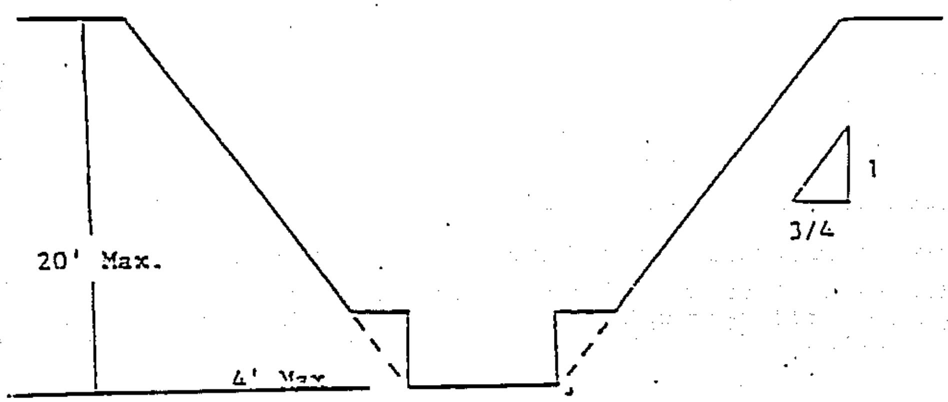
SIMPLE SLOPE—GENERAL

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of ½:1.

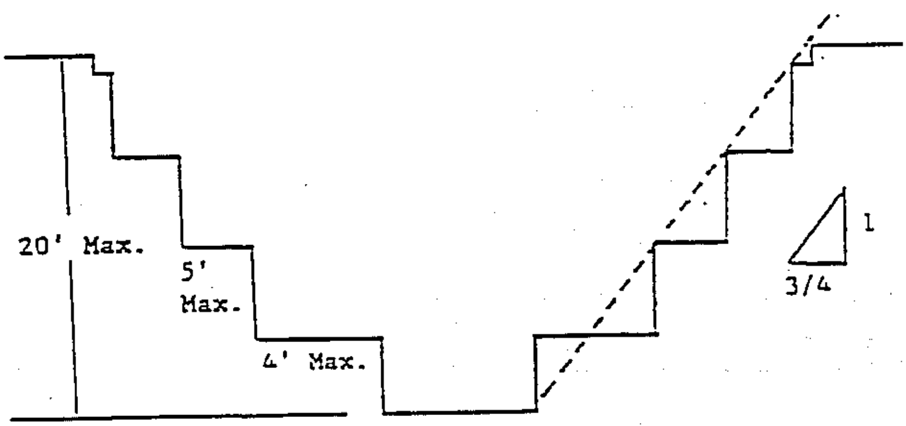


SIMPLE SLOPE—SHORT TERM

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:

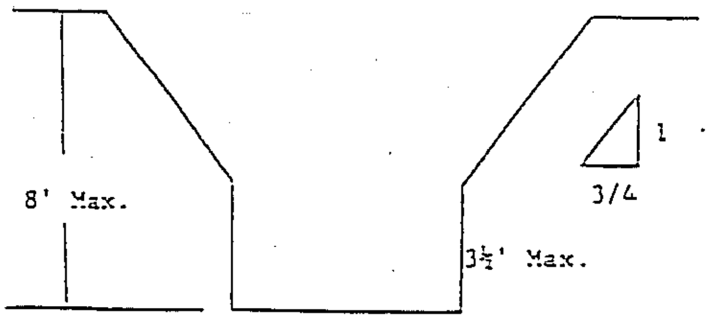


SIMPLE BENCH



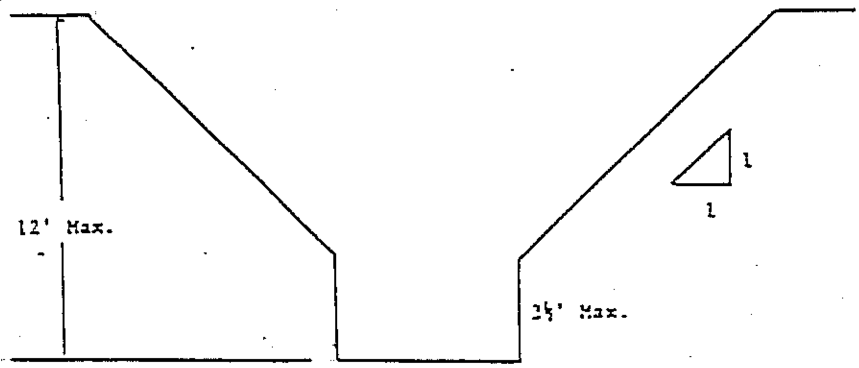
MULTIPLE BENCH

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



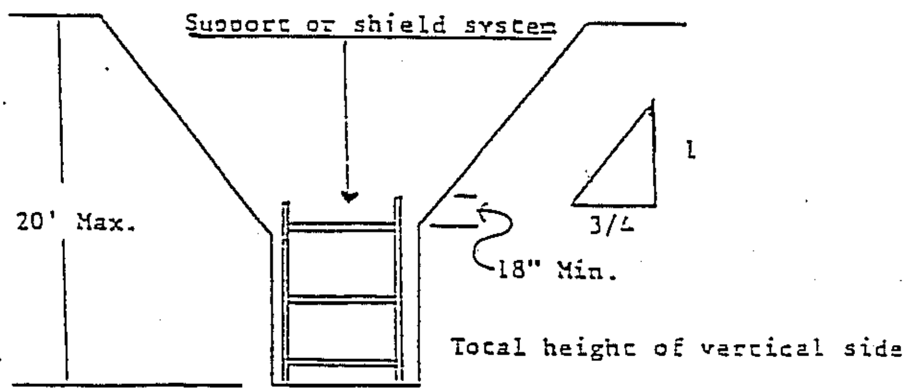
UNSUPPORTED VERTICALLY SIDED LOWER PORTION—MAXIMUM 8 FEET IN DEPTH

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



UNSUPPORTED VERTICALLY SIDED LOWER PORTION—MAXIMUM 12 FEET IN DEPTH

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ¾:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

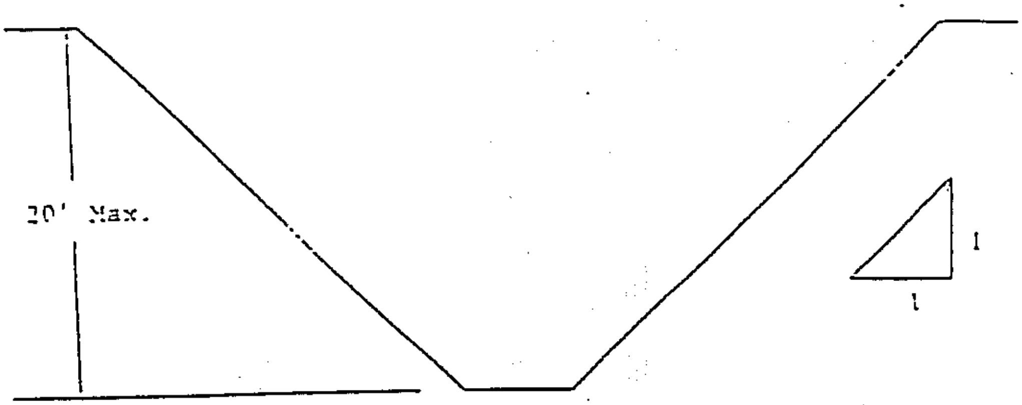


SUPORTED OR SHIELDED VERTICALLY SIDED LOWER PORTION

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

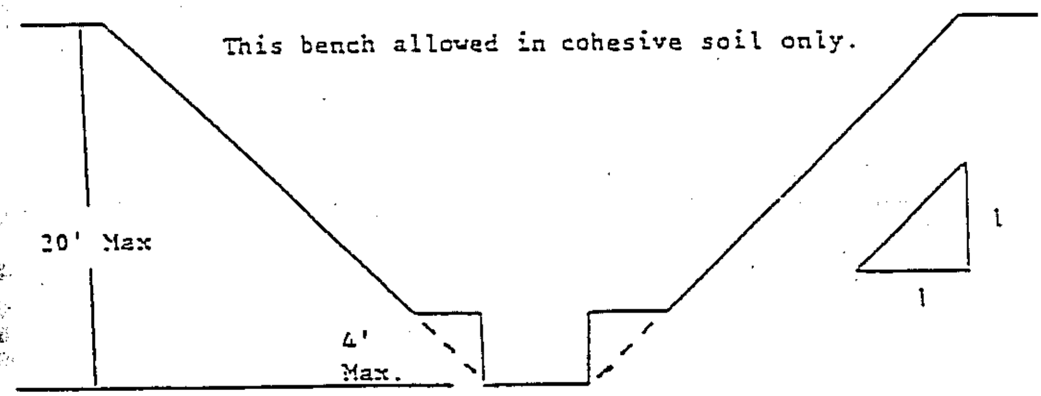
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

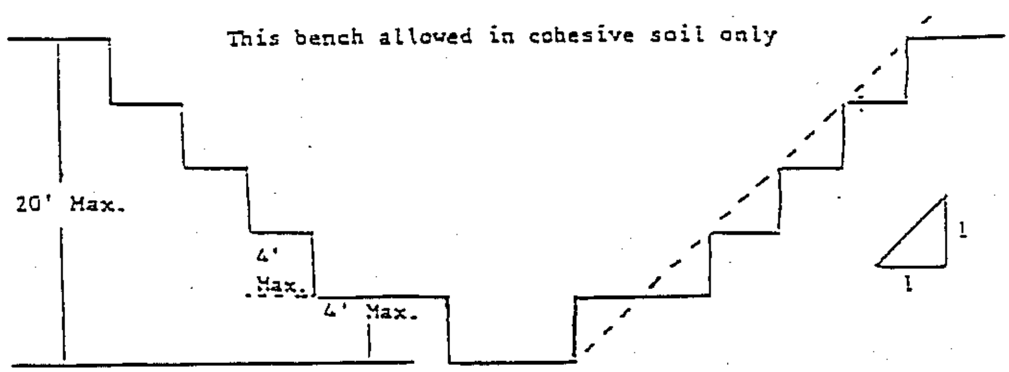


SIMPLE SLOPE

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

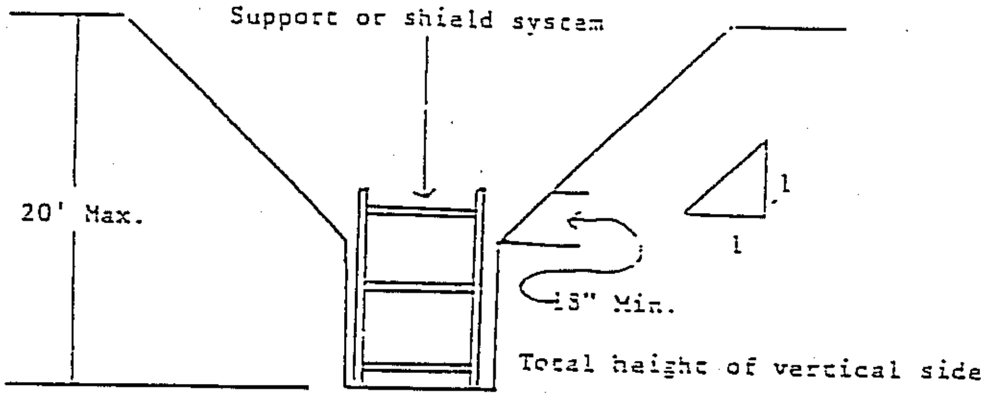


SINGLE BENCH



MULTIPLE BENCH

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

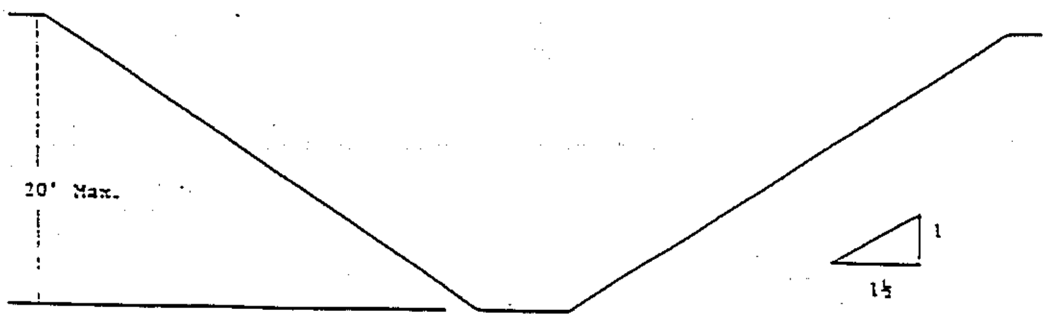


VERTICALLY SIDED LOWER PORTION

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

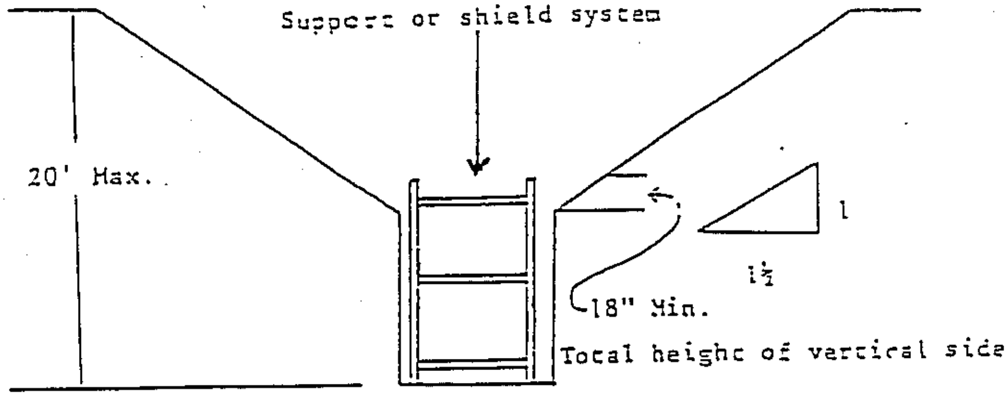
B-1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.



SIMPLE SLOPE

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

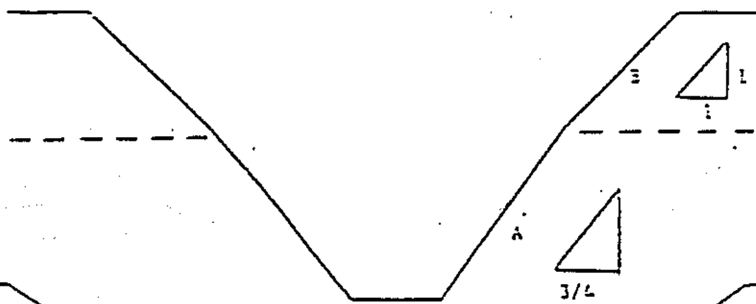


VERTICAL SIDED LOWER PORTION

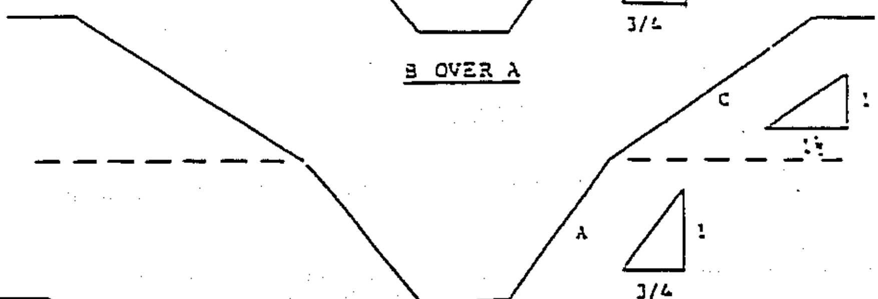
3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

B-1.4 Excavations Made in Layered Soils

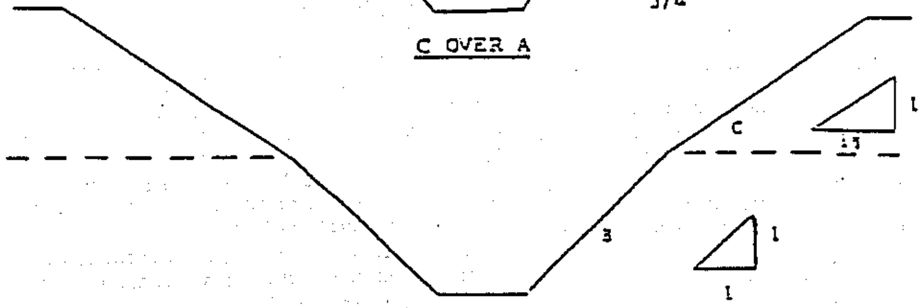
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



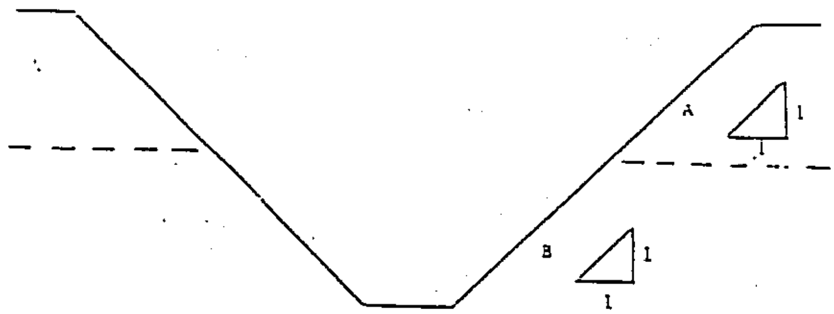
B OVER A



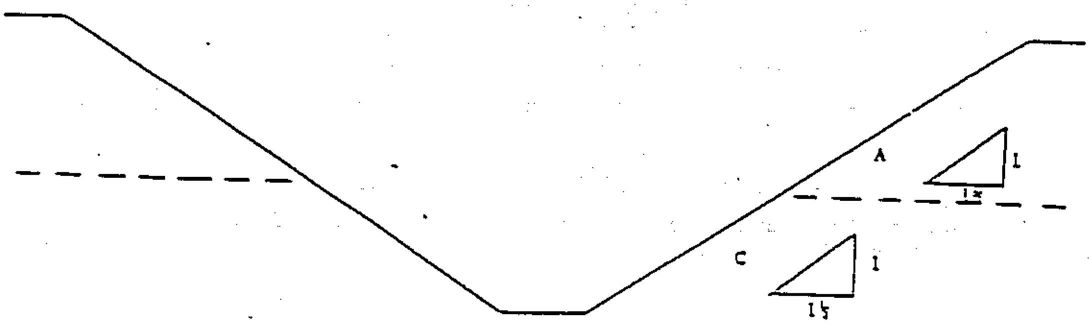
C OVER A



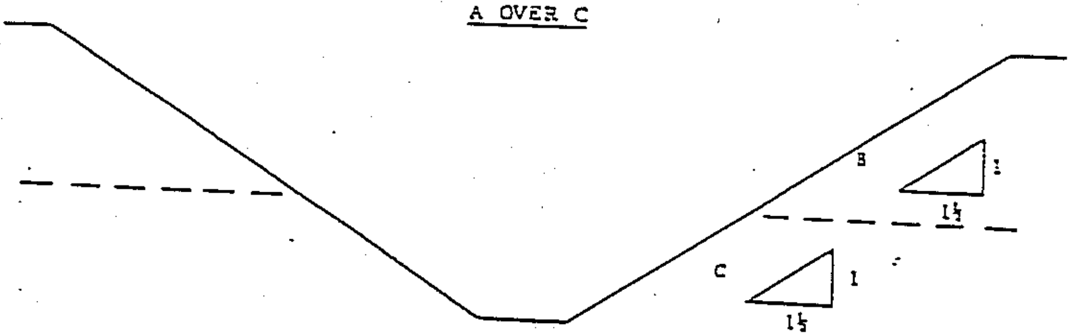
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).

Appendix C to Subpart P

Timber Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with § 1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in § 1926.652(b) and § 1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2, and C-1.3, and

Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.

(d) *Basis and limitations of the data.*—(1) *Dimensions of timber members.* (i) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under § 1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.* (i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with § 1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables.* The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) *Examples to Illustrate the Use of Tables C-1.1 through C-1.3.*

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide.

From *Table C-1.1*, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4×4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3×8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4×6 crossbraces at eight feet horizontally and four feet vertically.

Space 8×8 wales at four feet vertically.

Space 2×6 uprights at four feet horizontally.

Arrangement #3

Space 6×6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8×10 wales at four feet vertically.

Space 2×6 uprights at five feet horizontally.

Arrangement #4

Space 6×6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10×10 wales at four feet vertically.

Spaces 3×8 uprights at six feet horizontally.

(2) *Example 2.*

A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1

Space 6×6 crossbraces at six feet horizontally and five feet vertically.

Space 8×8 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #2

Space 6×8 crossbraces at eight feet horizontally and five feet vertically.

Space 10×10 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement #3

Space 8×8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Space 2×6 uprights at two feet vertically.

(3) *Example 3.*

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8×8 crossbraces at six feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Position 2×6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8×10 crossbraces at eight feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Position 2×6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) *Example 4.*

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8×10 crossbraces at six feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Use 3×6 tight sheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) *Notes for all Tables.*

1. Member sizes at spacings other than indicated are to be determined as specified in § 1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

TABLE C-1.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A $P_a = 25 \times H + 72$ psf (2 ft Surcharge)

PTH OF ENCH ET)	SIZE (ACTUAL) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				2X6	
0	UP TO 8	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---					2X8
10	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			2X6		
	UP TO 12	4X6	4X6	6X6	6X6	6X6	4	8X8	4				2X6	
10	UP TO 6	4X4	4X4	4X6	6X6	6X6	4	Not Req'd	---				3X8	
0	UP TO 8	4X6	4X6	6X6	6X6	6X6	4	8X8	4		2X6			
15	UP TO 10	6X6	6X5	6X6	6X8	6X8	4	8X10	4			2X6		
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	10X10	4				3X8	
5	UP TO 6	6X6	6X6	6X6	6X8	6X8	4	6X8	4	3X6				
)	UP TO 8	6X6	6X6	6X6	6X8	6X8	4	8X8	4	3X6				
)	UP TO 10	8X8	8X8	8X8	8X8	8X10	4	8X10	4	3X6				
	UP TO 12	8X8	8X8	8X8	8X8	8X10	4	10X10	4	3X6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET) UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15	VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) CLOSE	2	3		
5 TO 10	UP TO 6	4X6	4X6	6X6	6X6	6X6	5	6X8	5			2X6		
	UP TO 8	6X6	6X6	6X6	6X8	6X8	5	8X10	5			2X6		
	UP TO 10	6X6	6X6	6X6	6X8	6X8	5	10X10	5			2X6		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5		2X6			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5		2X6			
	UP TO 10	8X8	8X8	8X8	8X8	8X10	5	10X12	5		2X6			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	3X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	3X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may by substituted for wood.

TABLE C-1.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C P_a = 80 X H + 72 psf (2 ft. Surcharge)

DEPTH OF NCH (ET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**													
	CROSS BRACES									UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET) UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15	VERT. SPACING (FEET)	SIZE (IN.)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) (See Note 2) CLOSE				
5 TO 0	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	2X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6				
	See Note 1													
0 0 5	UP TO 6	8X8	8X8	8X8	8X8	8X10	5	10X12	5	2X6				
	UP TO 8	8X10	8X10	8X10	8X10	10X10	5	12X12	5	2X6				
	See Note 1													
	See Note 1													
5 0 20	UP TO 6	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
	See Note 1													
	See Note 1													
	See Note 1													
ER)	SEE NOTE 1													

.* Mixed Oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.1

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE A P_a = 25 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4X4	4X4	4X4	4X4	4X6	4	Not Req'd	Not Req'd				4X6	
	UP TO 8	4X4	4X4	4X4	4X6	4X6	4	Not Req'd	Not Req'd					4X8
	UP TO 10	4X6	4X6	4X6	6X6	6X6	4	8X8	4			4X6		
	UP TO 12	4X6	4X6	4X6	6X6	6X6	4	8X8	4				4X6	
10 TO 15	UP TO 6	4X4	4X4	4X4	6X6	6X6	4	Not Req'd	Not Req'd				4X10	
	UP TO 8	4X6	4X6	4X6	6X6	6X6	4	6X8	4		4X6			
	UP TO 10	6X6	6X6	6X6	6X6	6X6	4	8X8	4			4X8		
	UP TO 12	6X6	6X6	6X6	6X6	6X6	4	8X10	4		4X6		4X10	
15 TO 20	UP TO 6	6X6	6X6	6X6	6X6	6X6	4	6X8	4	3X6				
	UP TO 8	6X6	6X6	6X6	6X6	6X6	4	8X8	4	3X6	4X12			
	UP TO 10	6X6	6X6	6X6	6X6	6X8	4	8X10	4	3X6				
	UP TO 12	6X6	6X6	6X6	6X8	6X8	4	8X12	4	3X6	4X12			
OVER 20	SEE NOTE 1.													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.2

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE B P_a = 45 X H + 72 psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5	UP TO 6	4X6	4X6	4X6	6X6	6X6	5	6X8	5			3X12 4X8		4X12
TO	UP TO 8	4X6	4X6	6X6	6X6	6X6	5	8X8	5		3X8		4X8	
0	UP TO 10	4X6	4X6	6X6	6X6	6X8	5	8X10	5			4X8		
	See Note 1													
0	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5	3X6	4X10			
TO	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5	3X6	4X10			
5	UP TO 10	6X8	6X8	8X8	8X8	8X8	5	10X12	5	3X6	4X10			
	See Note 1													
5	UP TO 6	6X8	6X8	6X8	6X8	8X8	5	8X10	5	4X6				
TO	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X12	5	4X6				
0	UP TO 10	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6				
	See Note 1													
VER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

TABLE C-2.3

TIMBER TRENCH SHORING -- MINIMUM TIMBER REQUIREMENTS *

SOIL TYPE C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS **														
	CROSS BRACES							WALES		UPRIGHTS					
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)					
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE					
5 TO 10	UP TO 6	6X6	6X6	6X6	6X6	8X8	5	8X8	5	3X6					
	UP TO 8	6X6	6X6	6X6	8X8	8X8	5	10X10	5	3X6					
	UP TO 10	6X6	6X6	8X8	8X8	8X8	5	10X12	5	3X6					
	See Note 1														
10 TO 15	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	10X10	5	4X6					
	UP TO 8	8X8	8X8	8X8	8X8	8X8	5	12X12	5	4X6					
	See Note 1														
	See Note 1														
15 TO 20	UP TO 6	8X8	8X8	8X8	8X10	8X10	5	10X12	5	4X6					
	See Note 1														
	See Note 1														
	See Note 1														
OVER 20	SEE NOTE 1														

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

APPENDIX D TO SUBPART P

Aluminum Hydraulic Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with § 1926.652(c)(2).

(b) *Soil Classification.* In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables D-1.1, D-1.2, D-1.3 and E-1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D-1.2 are for vertical shores in Types A and B soil. Tables D-1.3 and D1.4 are for horizontal waler systems in Types B and C soil.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations (footnotes) regarding Table D-1.1 through D-1.4 are presented in paragraph (g) of this appendix.

(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring: Typical Installations."

(d) *Basis and limitations of the data.*

(1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D-1 Tables. Aluminum material is 6061-T6 or material of equivalent strength and properties.

(2) Hydraulic cylinders specifications. (i) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufaturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) Limitation of application.

(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in § 1926.652(c).

(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with § 1926.652.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables D-1.1, D-1.2, D-1.3 and D-1.4.* The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D-1.1 and D-1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D-1.3 and D-1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

(f) *Example to Illustrate the Use of the Tables:*

(1) Example 1:

A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D-1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:

A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per footnote (g)(7) to the D-1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D-1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D-1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) *Footnotes, and general notes, for Tables D-1.1, D-1.2, D-1.3, and D-1.4.*

(1) For applications other than those listed in the tables, refer to § 1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to § 1926.652(c)(2) and § 1926.652(c)(3).

(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5×3.5×0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities. (i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.

(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch. thick, 14 ply, arctic white birch (Finland form). Please note that, plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) See appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See appendix D, item (d), for basis and limitations of the data.

ALUMINUM HYDRAULIC SHORING
TYPICAL INSTALLATIONS

FIGURE NO. 1
VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING)

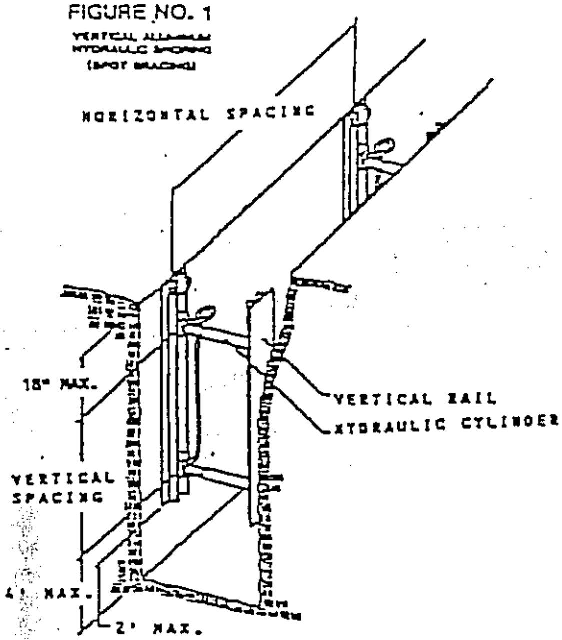


FIGURE NO. 2
VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD)

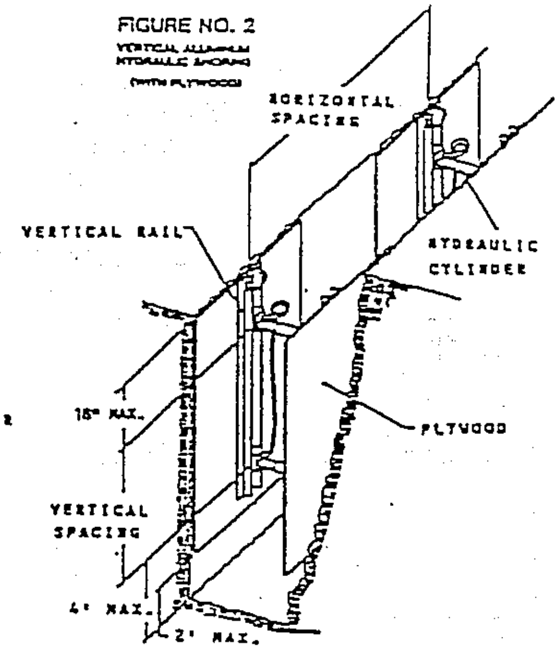


FIGURE NO. 3
VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)

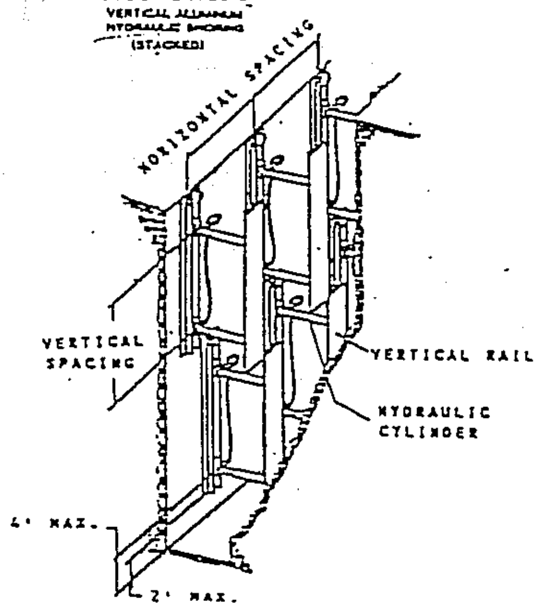


FIGURE NO. 4
ALUMINUM HYDRAULIC SHORING WALER SYSTEM (TYPICAL)

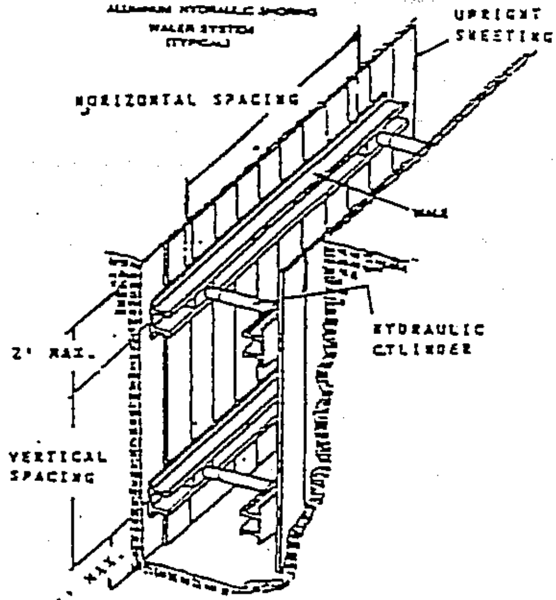


TABLE D - 1.1
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE A

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	8				
OVER 15 UP TO 20	7				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g) (1)
Note (2): See Appendix D, Item (g) (2)

TABLE D - 1.2
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES
FOR SOIL TYPE B

EPTH OF TRENCH (EET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 P TO 10	8				
VER 10 UP TO 15	6.5	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 15 P TO 20	5.5				
'ER 20	NOTE (1)				

es to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
): See Appendix D, Item (g) (1)
(2): See Appendix D, Item (g) (2)

TABLE D - 1.3
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE B

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX.HORIZ.SPACING (ON CENTER)		
	VERTICAL SPACING (FEET)	SECTION MODULUS (IN^3)	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN NOTE(2)	8.0	3 IN	—	—	3x12
		7.0	9.0	2 IN	9.0	2 IN NOTE(2)	9.0	3 IN			
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	—	3x12	—
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN NOTE(2)	5.5	3 IN	3x12	—	—
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g) (1)
Notes (2): See Appendix D, Item (g) (2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

TABLE D - 1.4
ALUMINUM HYDRAULIC SHORING
WALER SYSTEMS
FOR SOIL TYPE C

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX.HORIZ SPACING (ON CENTER)		
	VERTICAL SPACING (FEET)	SECTION MODULUS* (IN³)	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE(2)	6.0	3 IN	3x12	—	—
		7.0	6.5	2 IN	6.5	2 IN NOTE(2)	6.5	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE(2)	4.0	3 IN	3x12	—	—
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE(2)	3.5	3 IN	3x12	—	—
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g) (1)
Notes (2): See Appendix D, Item (g) (2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

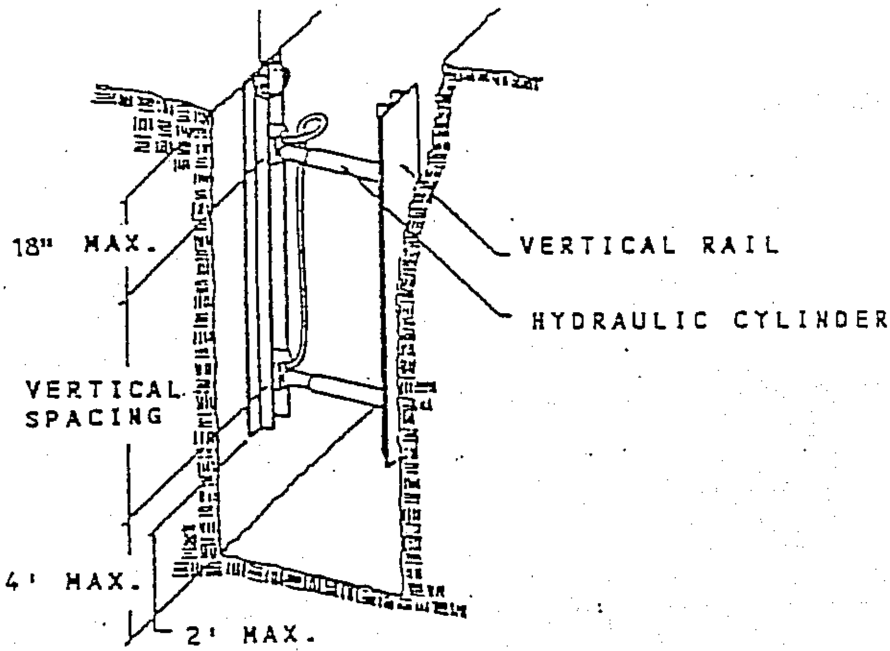


FIGURE 1. ALUMINUM HYDRAULIC SHORING

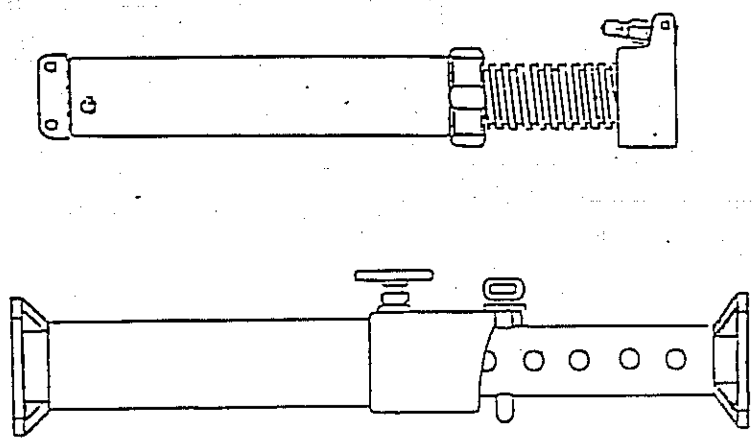


FIGURE 2. PNEUMATIC/HYDRAULIC SHORING

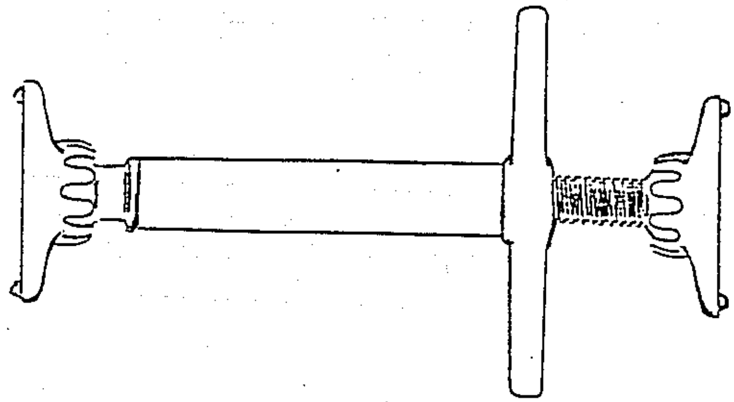


FIGURE 3. TRENCH JACK (SCREW JACK)

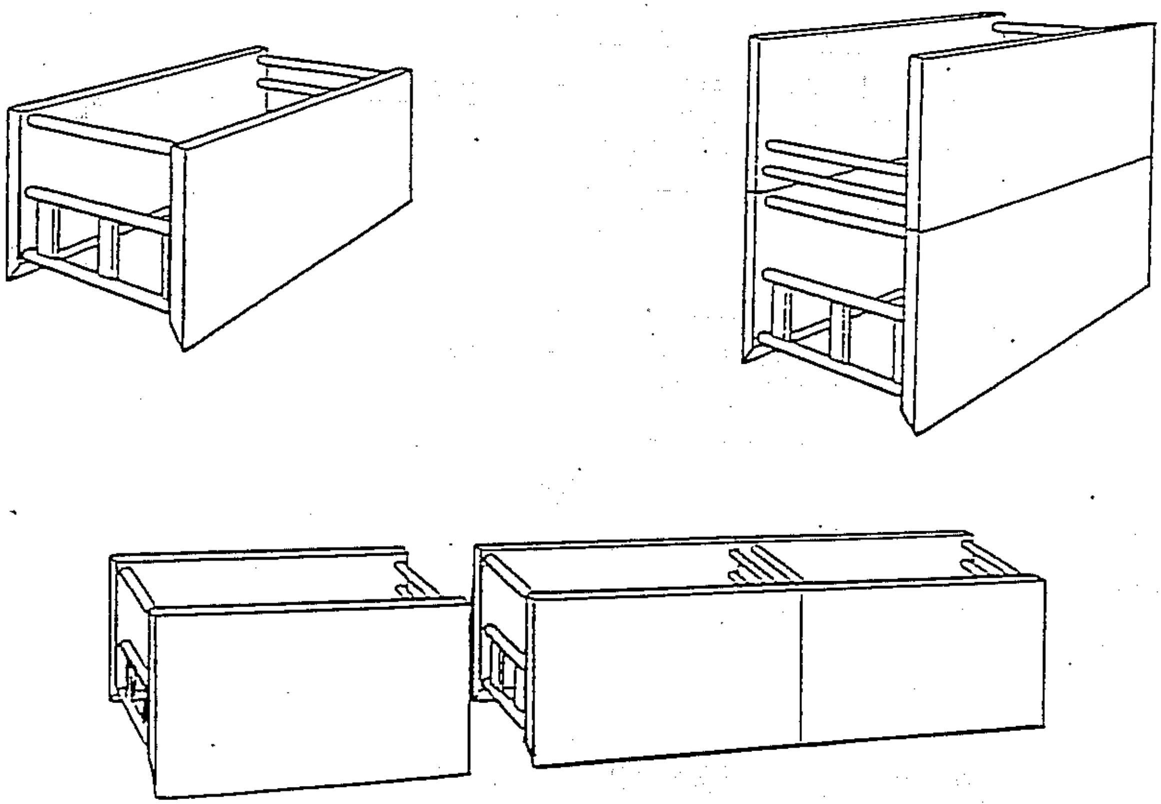


FIGURE 4. TRENCH SHIELDS

Appendix F to Subpart P—Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with § 1926.652 (b) and (c).

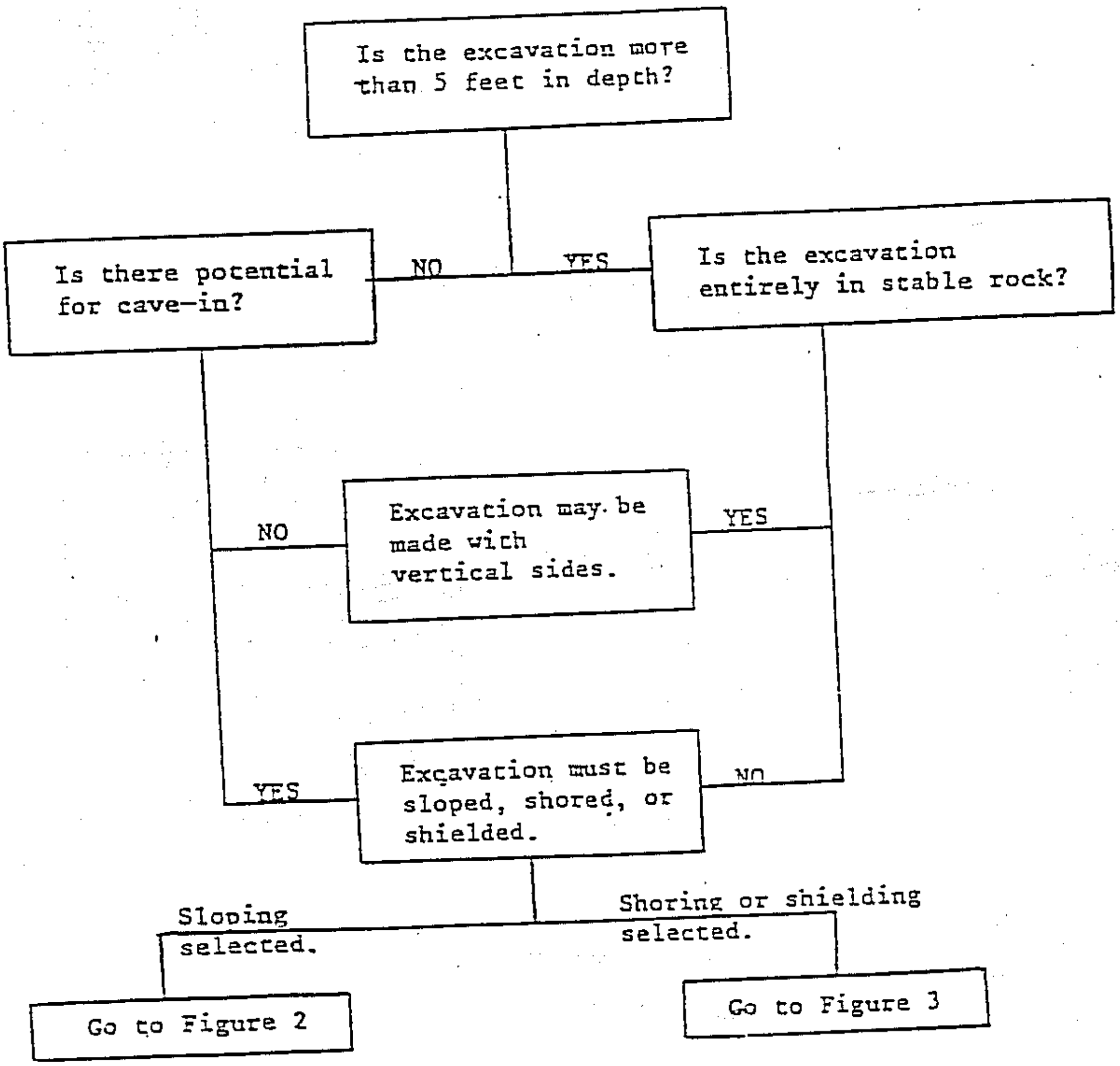


FIGURE 1 - PRELIMINARY DECISIONS

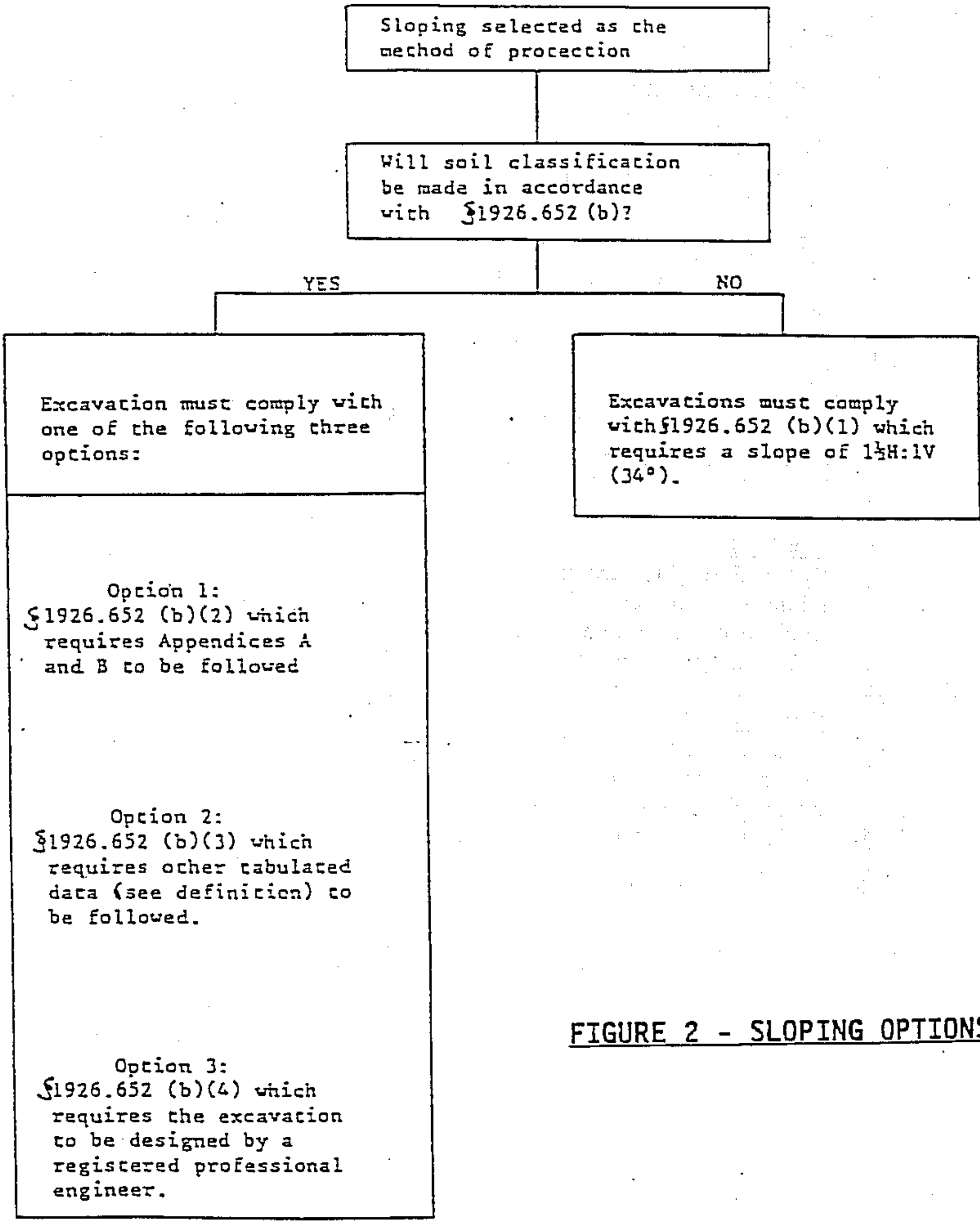


FIGURE 2 - SLOPING OPTIONS

Shoring or shielding selected
Soil classification is required when shoring or shielding is used. The excavation must comply with one of the following four options:
<u>Option 1</u> §1926.652(c)(1) which required Appendices A and C to be followed (e.g. timber shoring). <u>Option 2</u> §1926.652(c)(2) which requires manufacturers data to be followed (e.g. hydraulic shoring, trench jacks, air shores, shields). <u>Option 3</u> §1926.652(c)(3) which requires tabulated data (see definition) to be followed (e.g. any system as per the tabulated data). <u>Option 4</u> §1926.652(c)(4) which requires the excavation to be designed by a registered professional engineer (e.g. any designed system).

FIGURE 3 - SHORING AND SHIELDING OPTIONS